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Experiments on Water-Wheels, having a vertical axis, called Turbines. By ARTHUR MORIN, Captain of Artillery, Professor of Machinery in the School of Artillery, &c. &c. *Published at Metz, and Paris,* 1838.

(Translated from the French, by ELLWOOD MORRIS, Civil Engineer.)

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X.

Observations on the results of the Experiments.

The great velocity of the wheel, hindering our counting its revolutions by the eye, we arranged hard by a key-wedge, a spring-blade, which it struck at each turn, and two observers, guided by the sound, counted at the same time the number of turns made in one minute, repeating the experiments several times to ensure accuracy.

The total fall was measured for each experiment by the simultaneous observation of two floats, one placed above in the trough, and the other below in the lower basin. These floats, graduated, and marked at fixed points, were placed in little cases, and in situations suitable to protect their indications from the influence of undulations of the level (or waves.) The float below served also to determine the depth to which the lower ring of the *turbine* was immersed.

All these arrangements being made, we proceeded to the execution of the experiments, of which the results are recorded in the following table:

Experiments made in May, 1837, on the Turbine of the Power Weaving Establishment of Moussay, (Department of Vosges.)

Number of the experiments.	*Lift* of the sluice-gate of the Turbine.	*Charge* of water on the sill, or edge, of the *water-board*, 2.693 metres in breadth.	*Weight* of water expended per sec.	*Total fall.*	Absolute Work of Power expended by the Motor. No. of kilogrammes lifted one metre in one second.	Absolute Work of Power expended by the Motor. No. of horses-power of 75 kilogrammes lifted one metre in one second.	*Load* of the *Brake*, or Friction Dynamometer.	*Turns* of the wheel in *one minute.*	*Velocity* that the point of suspension of load tended to take in 1 *second.*	Useful effect measured by the Brake, or quantity of available force. No. of kilogrammes lifted one metre, in one second.	Useful effect measured by the Brake, or quantity of available force. No. of horses power lifted one metre, in *one second.*	*Ratio of Useful Effect* mea'd. by *Brake* to the total power expended by Motor.	*Depth* which the *Turbine* was immersed, measured above *lower ring.*
	Metres	Metres	Kil.	Mtrs.	Kilog.	Hrs. pr.	Kilg.	No.	Mtrs.	Kilog.	Hrs. pr.		Mtrs.
1	0.0500	0.179	362	7.091	2567	34.25	7.50	255	66.81	501	6.68	0.195	0.307
2	0.0490	0.179	362	7.056	2554	34.18	16.50	240	62.88	659	8.78	0.258	0.302
3	0 0465	0.179	362	7.160	2592	34.52	12.50	222	58.16	726	9 68	0.280	0.303
4	0.0500	0.184	372	7.255	2697	35.96	12.50	243	63.67	795	10.60	0.295	0.305
5	0.0500	0.1815	364	7.229	2624	35.00	15.50	228	59.74	925	12 33	0.352	0.301
6	0.0500	0.181	363	7.131	2588	34.51	17.50	221	57.90	1013	13.31	0.385	0.301
7	0.0500	0.1755	349	6.927	2419	32.26	20.50	210	55.02	1128	15.02	0 466	0.201
8	0.0470	0.185	373	7.127	2659	35.46	22 50	190	49.78	1120	14.93	0.420	0.296
9	0.0480	0.1755	349	7.313	2551	34.02	25.50	190	49.78	1267	16.89	0.497	0 295
10	0.0480	0.179	360	7.239	2606	34.75	27.50	178	46.64	1281	17.08	0.496	0.296
11	0.0480	0.176	351	7.294	2553	34.04	30.50	168	44.02	1342	17.89	0.525	0.294
12	0.0480	0.176	351	7.134	2504	33.39	32.50	163	42.71	1387	18.49	0.553	0.294
13	0.0480	0.174	345	7.034	2427	32.36	35.50	153	40.09	1423	18.97	0.586	0.294
14	0.0480	0.175	348	6.854	2384	31.78	37.50	152	39.82	1492	19.89	0.626	0.294
15	0.0470	0.187	378	7.395	2795	37.27	40.50	146	38.25	1547	20.62	0.553	0.293
16	0.0510	0.188	387	7.375	2854	38.05	42.50	152	39.82	1691	22.54	0.593	0.293
17	0.0510	0.184	375	7.087	2657	35.43	47.50	135	35.37	1667	22.22	0.627	0.293
18	0.0500	0.181	366	6.911	2529	34.05	52.50	108	29.30	1486	19.80	0.587	0.287
19	0.075	0.230	523	7.278	3807	50.76	32.50	240	62.88	2044	27.25	0 587	0.395
20	0.072	0.233	534	7.333	3914	52.20	37.50	228	59.74	2238	29.84	0.572	0.360
21	0.079	0.235	540	7.105	3837	51.16	42.50	227	59.47	2528	33.70	0.659	0.353
22	0.073	0.235	540	7.285	3934	52.45	47.50	207	54.23	2574	34.32	0 654	0.350
23	0.073	0.227	515	7.150	3682	49.06	52.50	173	45.33	2378	31.70	0.643	0.348
24	0.071	0.226	523	6.951	3635	48.46	57.50	150	39.30	2260	30.12	0.622	0.342
25	0.071	0.228	524	6.986	3633	48.44	62.50	138	36.16	2257	30.08	0.621	0.342
26	0.071	0.225	522	7.017	3633	48.84	67.50	120	31.44	2119	28.25	0.578	0.341
27	0.071	0.224	512	7.019	3594	47.92	72.50	106	27.77	2015	26.86	0.561	0.341
28	0.071	0.222	502	7.002	3515	47.00	77.50	98	25.68	1984	26.45	0.563	0.341
29	0 071	0.224	512	6.994	3579	47.72	82.50	84	22.01	1816	24.20	0.506	0.343
30	0.071	0.227	515	7 046	3629	48 38	87.50	76	19.91	1742	23.20	0.480	0.342
31	0.071	Measurement by waste-board omitted.	525	7.522	3948	52.64	42.50	222	58.16	2472	32.95	0.626	0.256
32	0.071		527	7.562	3984	53.12	52.50	201	52.66	2765	36.86	0.696	0 256
33	0.071		527	7.563	3985	53.13	62.50	158	41.40	2587	34.49	0 651	0.255
34	0.071		527	7.554	3979	53.03	72.50	130	34.02	2466	32.88	0.623	0 264
35	0.071		529	7.554	3920	52.30	82.50	102	26.72	2204	29 39	0.561	0.264
36	0.071		527	7.556	3979	53.05	92.50	80	20.96	1939	25.85	0.486	0.282

Experiments at Moussay—Continued.

Number of the experiments.	*Lift* of the sluice-gate of the Turbine.	*Charge* of water on the sill, or edge, of the *waste board*, 2.682 metres in breadth.	*Weight* of water expended in *one second.*	*Total fall.*	Absolute Work or Power expended by the Motor.		*Load* of the *Brake*, or Friction Dynamometer.	*Turns* of the wheel in *one minute.*	*Velocity* that the point of suspension of the load tended to take *per sec.*	Useful Effect measured by the Brake, or quantity of available power.		*Ratio* of *Useful Effect* meas'd. by *Brake*, to total power expended by the Motor.	*Depth* which the *Turbine* was immersed, measured above *lower ring.*
					No. of kilogrammes lifted one metre in one second.	No. of horses-power of 75 kilogrammes lifted one metre in one second.				No. of Kilogrammes lifted one metre in one second.	No. of horses-power lifted one metre in one second.		
	Mtrs.	Measurement by waste-board omitted, and quantities of water calculated by the coefficients of discharge of the Turbine orifices.	Kilo.	Mtrs.	Kilog.	Hrs. pr.	Kilo.	No.	Mtrs.	Kilog.	Hrs. pr.		Mtrs
37	0.086		616	7.421	4571	60.94	42.50	250	65.50	2784	37.11	0.609	0.352
38	0.086		618	7.476	4622	61.63	52.50	220	57.64	3024	40.32	0.655	0.342
39	0.086		620	7.484	4638	61.80	62.50	184	48.21	3013	40.16	0.650	0.334
40	0.086		620	7.498	4649	61.99	72.50	155	40.61	2944	39.25	0.634	0.320
41	0.086		620	7.503	4657	62.09	82.50	128	33.14	2734	36.45	0.586	0.305
42	0.086		620	7.511	4664	62.19	92.50	108	28.30	2617	34.89	0.562	0.287
43	0.107		729	6.779	4943	65.90	42.50	250	65.50	2784	37.11	0.562	0.974
44	0.107		730	6.858	5008	66.77	52.50	240	62.88	3302	44.03	0.657	0.930
45	0.107		732	6.911	5058	67.44	62.50	208	54.50	3406	45.41	0.675	0.887
46	0.107		736	6.942	5115	64.87	72.50	169	44.29	3212	42.82	0.662	0.856
47	0.107		736	6.950	5115	64.87	82.50	144	37.73	3110	41.87	0.640	0.848
48	0.107		738	6.965	5137	68.49	92.50	122	31.96	2957	39.40	0.560	0.836

Observations on the foregoing Table.

In the experiments from 31 *to* 48 *inclusive*, we had removed the wasteboard, to enable us to use the whole of the ordinary fall.

In the experiments from 37 *to* 42 *inclusive ;* to calculate the quantity of water emitted in *one second*, we took 0.86 for the coefficient of the discharge due to the orifices of the *turbine.*

In the experiments from 43 *to* 48 *inclusive ;* to calculate the volume of water emitted in *one second*, we took 0.83 for the cofficient of discharge due to the orifices of the *turbine :* and we had increased the depth, to which the turbine was submerged, by a stop-gate in the tail-race (so as to flood it with back water).

[NOTE.—Instead of the name *Friction Dynamometer*, we shall, hereafter, use its synonyme, *Brake*.—Trans.]

XI.

Discussion and graphic representation of the results contained in this Table.

To examine and discuss the results contained in this table, we have constructed the curves below, of which the abscisses are the number of turns made by the wheel in *one minute*, and the ordinates represent the ratios of the useful effect measured by the *brake*, or of the available work, to the total power expended by the *motor.*

In tracing the curves through all the points thus determined for

each series in the best possible way to represent the whole of the results, we have obtained one prolonged graphic law, free from the accidental irregularities of the observations. It is by the aid of an examination of these curves that we shall discuss the results of the experiments.

The curve, Fig. 1, Plate I, which relates to the series where the lift of the *sluice-gate* was at a mean 0.050 metres, or $\frac{16}{100}$ of a foot, shows that the maximum of effect corresponded to a velocity of 135 turns in *one minute*, and that then the ratio of the useful effect, to that of the total power of the motor, was equal to about 0.61, although the calculation, based on the corresponding experiment, had given 0.625. But we see that from the velocity of 100 turns, to that of 170 turns per minute, this ratio has always been comprised between 0.565 and 0.610, so that even within these wide limits, it has not varied more than $\frac{1}{13}$th of its mean value, 0.587.

The curve, Fig. 2, Plate I, relating to the series of experiments where the lift of the *sluice-gate* of the *turbine* was 0.071 metres, or $\frac{23}{100}$ of a foot, shows that the maximum effect corresponded to the velocity of 190 turns in *one minute*, and that then the ratio of the useful effect, to the total power of the motor, was equal to 0.680, although the calculation, based upon experiment, had given 0.696. We see also that from the velocity of 130 turns, to that of 230 turns in *one minute*, this ratio has always been comprised between 0.625 and 0.680; so that even between these wide limits, it has varied only about $\frac{1}{12}$th of its mean value, 0.652.

The curve, Fig. 3, Plate I, relates to the series where the lifts of the sluice-gate of the turbine had been 0.086 metres, or $\frac{28}{100}$ of a foot, and 0.107 metres, or $\frac{35}{100}$ of a foot; these we have united to obtain a more correct trace, but we have distinguished the points of each by particular signs. This curve shows that the maximum effect corresponded to a velocity of from 180 to 190 turns in *one minute*, and that then the ratio of the useful effect, to the total power of the motor, was equal to 0.690. We see also that from the velocity of 140 turns, to that of 230 turns in *one minute*, this ratio has always been comprised between 0.650 and 0.690; so that between these wide limits it varied only $\frac{1}{17}$th of its mean value, 0.675.

It evidently follows from this discussion, that this wheel possesses the very remarkable and advantageous property of moving at extremely different velocities without much variation in its useful effect.

XII.

Observations on the advantage which this wheel possesses of being able to move at very different velocities (without much variation of useful effect.)

In many manufactures the velocity of the tool, and, consequently of the working point, must vary with the degree of forwardness of the work, and as it is always of importance to realize the maximum effect due to each case, the signal advantage of the turbine for such works is evident. But it is not less in those where the velocity is required to remain constant, even though the height of the

available fall should vary considerably, either from the depression of the upper level, or the exhaustion of the lower; for the velocity of the wheel corresponding to the maximum effect depending on the total height of this fall, it follows that to obtain this maximum, we must contrive that the velocity of the wheel shall vary with the fall, but this, by hypothesis, the nature of the manufacture does not permit; whilst, by the property which these *turbines* have of being able to move at velocities very different from that which corresponds to the maximum effect, without the useful effect differing much from this limit, we see that with it we shall be able always to give to the tools, the velocity proper for the work, without losing any considerable part of the power of the motor. We shall see, by experiments, reported farther on, that this constancy of the useful effect held good for falls very different from those of Moussay.

XIII.

Remarks relative to the experiments in which the wheel was entirely submerged by backwater.

We shall observe also that in the experiments recorded in the preceding table, the level of the water below, rose, for the first series, to (0.300 m.) $\frac{98}{100}$ of a foot, above the lower ring of the turbine, and for the last series, to near (a metre) $3\frac{28}{100}$ feet, and that, nevertheless, the useful effect observed in this last series, has not been less, though the backwater was greater, than in the preceding. This result confirmed those which have been observed on the turbine of Moal, and shows again, that these wheels can move, when immersed, without their useful effect being sensibly diminished by the resistance of the water which surrounds them.

XIV.

Observation on the increase of the useful effect in proportion as the lift of the sluice-gate augments.

We shall now observe that the useful effect is perceptibly greater for those lifts of the sluice-gate which approach to the height of the turbine, than for those which are less; but as this effect is exhibited in a way more evident in the experiments made at Müllbach, we reserve the explanation of it for that part of the subject. Nevertheless, we shall remark, that with a lift of the sluice-gate of $\frac{16}{100}$ of a foot (0.05 m.), nearly half of the height of the turbine, the useful effect is about 0.61 of the absolute work, or power, expended by the motor, and it approached more nearly to the value 0.69, when the lift reached (0.107 m.) $\frac{35}{100}$ of a foot, (or nearly the whole height of the *turbine.)*

XV.

Summary of the results drawn from these experiments.

1. That the wheel of the weaving establishment of Moussay, which had but about (0.85 m.) $2\frac{79}{100}$ feet of external diameter, and (0.11 m.) $\frac{36}{100}$ feet of height of ring, under a fall of (7.50 m., or 24 $\frac{61}{100}$ feet,) is able to vent a volume of water of (0.738 cub. m.) $26\frac{04}{100}$ cub. feet in

a second; and, moreover, that it then transmitted *a useful effect, or available power, of more than* 45 *horses, each equal to* (75 kil. lifted 1 m. in 1 sec.) 32,553 *lbs. lifted one foot high in a minute.* [Which is so nearly the same as the *horse-power* of Boulton and Watt's steam standard, that it may be taken as identical therewith, which will be hereafter understood whenever the phrase *horse-power* is used.—Tr.]

2. That with the velocity of 180 to 190 turns in a minute, it returned, in available power, 0.69 of the absolute power expended by the motor, (or the *effect* produced, was to the *power* expended, as 0.69 to 1.)

3. That the velocity of the wheel may vary within very wide limits, without the useful effect abating more than $\frac{1}{12}$th to $\frac{1}{15}$th of its maximum value.

4. That the ratio of the useful effect to the power expended, does not diminish, when the wheel is submerged by backwater.

Experiments on the Turbine of the Power Weaving Establishment of Müllbach (Lower Rhine).

XVI.

Summary Description.

The power weaving establishment constructed in 1837, at Müllbach, in the department of the lower Rhine, has, for its motor, a *turbine* of about (2 m.) $6\frac{56}{100}$ feet in diameter; the mean power of which ought to be 45 horses. In compliance with my request, the intelligent proprietors, the Messrs. Sellière, Heevoot & Co., readily consented to make all the arrangements necessary for submitting this wheel to experiment. M. Schedecker, their partner, director of the spinning factory of Lutzelhausen, and also of this, willingly took upon himself to make suitable preparations; and on the 28th, 29th, and 30th of last July, the experiments were made in presence of M. Schedecker, M. Fourneyron, and several manufacturers and civil engineers.

The turbine is situated at the end of the canal of supply, in a chamber of (6.55 m. by 5.70 m.) $21\frac{49}{100}$ feet by $18\frac{70}{100}$ feet, in the floor of which is placed the cylinder which contains the sluice-gates. A hollow pipe which rises vertically, supports, by its lower extremity, the plate on which the curved guides are fixed, and it joins, by its upper extremity, to the apparatus which serves for raising the sluice-gate, and which receives the supports of the end of the lying shaft.

The shaft of the turbine enters within this cylinder, and passes out by the top, where it receives a beveled wheel, which transmit the motion to the lying shaft of the workshop, into which this shaft enters a little below the ground floor.

The *turbine* is placed below the floor of the water chamber, so that when this chamber is full, we cannot see either the sluices, or the wheel. The canal of escape, of which the direction is perpendicular to that of the canal of supply, has (6.40 m.) 21 feet of breadth, and is arched over for (20 m.) $65\frac{62}{100}$ feet beyond the building of the factory, under which it passes.

The work is fed by the waters of the Brasche, and the total fall is usually (4.50 m.) $14\frac{76}{100}$ feet; but at the time when these experiments were made, the stop-gate, which ought to withdraw the waters of the river into the canal of supply, was not yet executed, and the greatest fall of which we had the power to dispose, was only (3.70 m.) $12\frac{14}{100}$ feet. In freshets, the wheel becomes immersed, and it was so during all the experiments, to a depth which varied from about (0.520 m.) $1\frac{71}{100}$ feet, to (0.90 m.) $2\frac{95}{100}$ feet.

XVII.

Gauge of the expenditure of water.

To operate easily and accurately in gauging the expense of water, we had established at the end of the arch of the canal of escape, a stop-gate with an overfall, or waste-board, of (5.014 m.) $16\frac{45}{100}$ feet in breadth, of which the sill, or edge, formed by a thin plank of (0.027 m.) one inch thick, was (0.50 m.) $1\frac{64}{100}$ of a foot, to (0.60 m.) $1\frac{97}{100}$ of a foot from the bottom, and of which the vertical sides were each at (0.70 m.) $2\frac{30}{100}$ feet from the borders of the canal. The horizontal lines of reference established with care, admitted of easily measuring, at each experiment, the height of the level of the reservoir from (0.60m.) $1\frac{97}{100}$ of a foot upwards, and in the angles of the canal above the sill. From these circumstances of the establishment of this waste-board, or overfall, and the results of recent experiments made at Toulouse, and of which a part has been published by M. d'Aubuisson, we have taken to calculate the discharge of water in *one second*, the formula,

$$^{*}\,Q = 0.41\ LH\sqrt{2gH},$$

[which differs but a trifle from that already employed; see article VIII.—Trans.]

But the water chamber having its bottom, and one of its sides, of wood, the wood drying by the heat of the season, and not having time to swell sufficiently, since it was filled (with water,) leaked considerably at the joints, and this it was necessary to take into account. This we did at the beginning of each series of experiments, by observing the depth of water on the waste-board of the gauge, when the sluices of the turbine were closed. The results of these observations are shown in the table of the experiments, and the volume of water thus lost, has been deducted from that which corresponds to the charge observed on the waste-board during the experiments.

XVIII.

Arrangements made to measure the principal results.

For obtaining the total fall, we arranged a horizontal line of reference, at a known height, above the plane of the sluices upwards,

* I believe I ought to make the remark, that in those experiments, which I have published before, on the breast-wheel of the slitting mill of Balcarat, I have adopted the formula,

$$Q = 0.395\ LH\sqrt{2gH},$$

not knowing then of the experiments at Toulouse, this induced me to estimate the discharge at about 1.26th be ow its value.

from which we measured simultaneously the height of the water above, in the chamber of the turbine, and the height below, in the canal of escape. The difference gave, for each experiment, the available fall, and the excess of the height of the line of reference above the plane of the sluices, over the elevation of the same line above the water below, gave the depth to which the lower ring of the turbine was immersed.

XIX.

Of the Brake employed.

The brake was formed by a pulley of (1.25 m.) $4\frac{10}{100}$ feet in diameter, and of about (0.25 m.) $\frac{82}{100}$ of a foot broad at the throat, which had been turned with care, and well centred and wedged upon the upper part of the shaft of the turbine, which had not yet received the gearing which belonged there. The two jaws of this brake were of wood; the length of the lever measured perpendicularly to the direction of the cord to which the charge was suspended, was (2.99 m.) $9\frac{81}{100}$ feet. A cord fixed to the top of the wood work at (6 to 7 m.) $19\frac{63}{100}$ to $22\frac{97}{100}$ feet high, sustained the ends of the lever, and a plumb line indicated the position which it ought to preserve, so that its length should be perpendicular to the direction of the cord, which passed over a fixed pulley, sustaining the load.

XX.

Precautions to insure the regularity of the movement.

To maintain the surfaces in the same state of humidity, we introduced near the wheel, the fire engine of the establishment, and a watering pot was suspended above the cushion of the brake, in which a notch was made, whence the water poured on it. The men, in working the pump, directed a constant and regular current upon the rubbing surfaces, which were thus continually cooled and lubricated to the same degree. We obtained, in this manner, such regularity in the action of the brake, that, when under the same charge, it has sometimes moved more than one half hour without the least oscillation, so that the workman who superintended it, was not obliged to alter its screws. In one of the experiments, which we report, the oscillations of the lever below the vertical of the plumb-line, had not exceeded (0.02 to 0.03 m.) $\frac{6}{100}$ to $\frac{9}{100}$ of a foot either way, and the stay pieces disposed as a precaution, acted only during the moments of interruption.

We have not used a kilogramme of grease in making all these experiments, and, although I had frequently employed this dynamometrical apparatus with success, I had never seen it move with such perfect regularity.

Thus aided by these easy and very available means, I consider as entirely useless superfluities, all the modifications proposed, or adopted, by divers engineers, in the simple arrangement originally proposed by M. de Prony.

XXI.

Observations on the velocity of the Wheel.

The observations on the velocity of the wheel have been made almost always by two persons, and by repeated trials, by counting with second-watches, the number of turns made in *a minute*, by the shaft of the wheel.

The results of the experiments, and those that we deduce from them by calculation, are recorded in the following table.

Observations on the following Table.

In the experiments from 1 *to* 18 *inclusive;* the depth of water on the sill of the waste-board, arising from leakage, was 0.0265 m., which corresponds to *a loss of water of* 0.039 *cubic metres in a second*, which we have deducted from the volume which passed the waste-board during the experiments. It is the weight of the volume remaining, which is indicated by the fourth column.

In the experiments from 19 *to* 45 *inclusive;* the depth of the water on the sill of the waste-board, arising from the leakage, was 0.037 m., which corresponds to *a loss of water of* 0.064 *cubic metres in a second*, which we have deducted from the volume which passed the waste-board during these experiments.

In the experiments from 46 *to* 49 *inclusive;* the depth of the water on the sill of the waste-board, arising from leakage, was 0.038 m., which corresponds to *a loss of water of* 0.067 *cubic metres in a second*, and in the 46th experiment, it passed, besides in discharging 0.011 cubic metres in a second. These volumes expended, *in pure loss*, have all been deducted from those which passed the waste-board during the experiments.

In the experiments from 50 *to* 84 *inclusive;* the depth of the water on the sill of the waste-board, arising from leakage, was 0.038 m., which corresponds to *a loss of water of* 0.067 *cubic metres in a second*, which we have deducted from the volume of water which passed the waste-board during the experiments.

Experiments made in July, 1837, on the Turbine of the Power Weaving Establishment of Müllbach, in the Department of the Lower Rhine.

Number of the experiments.	Lift of the Sluice-gate.	Depth of water on the sill of the Waste-board, 5,014 m. in breadth.	Weight of water expended in one second.	Total Fall.	Absolute Power expended by the Motor: No. of kilogrammes lifted one metre in one second.	Absolute Power expended by the Motor: No. Horses-power.	Load of the Brake.	Turns of the Wheel in one minute.	Velocity which the point of susp'n. of load tended to take per second.	Useful Effect measur'd by the Brake, or quantity of available Power: No. of kilogrammes lifted 1 metre in 1 second.	Useful Effect measur'd by the Brake, or quantity of available Power: No. Horses-power.	Ratio of Useful Effect measured by the Brake, to the total power of the Motor.	Depth the Turbine was immersed, measured above the lower ring.
	Mtrs.	Mtrs.	Kilog.	Mtrs.	Kilog.	Hrs. pr.	Kilog.	No.	Mtrs.	Kilog.	Hr. pr.		Mtrs.
1	0.050	0.174	622.5	3.552	2208	29.44	8.13	72.0	22.54	183	2.44	0.083	0.520
2	"	0.174	622.5	3.547	2209	29.44	13.13	67.9	21.26	278	3.70	0.126	"
3	"	0.174	622.5	3.560	2213	29.51	18.13	64.8	20.48	371	4.93	0.167	"
4	"	0.174	622.5	3.580	2226	29.68	23.13	63.1	19.74	457	6.09	0.205	"
5	"	0.174	622.5	3.580	2226	29.68	28.13	60.0	18.80	429	7.00	0.238	"
6	"	0.174	622.5	3.565	2214	29.52	33.13	57.6	18.05	593	7.63	0.252	"
7	"	0.172	611.0	3.555	2170	28.93	38.13	55.3	17.35	662	8.82	0.306	"
8	"	0.172	611.0	3.565	2184	29.12	43.13	53.3	16.75	722	9.62	0.331	"
9	"	0.172	611.0	3.580	2187	29.16	48.13	50.7	15.90	765	10.20	0.350	"
10	"	0.173	610.0	3.585	2193	29.24	53.13	47.6	14.90	792	10.88	0.357	"
11	"	0.173	610.0	3.621	2208	29.44	58.13	43.9	13.76	800	10.99	0.373	"
12	"	0.173	610.0	3.621	2208	29.44	63.13	40.9	12.80	808	10.77	0.367	"
13	"	0.173	610.0	3.650	2223	29.64	68.13	37.5	11.72	798	10.64	0.360	"
14	"	0.173	610.0	3.680	2247	29.96	73.13	34.25	10.70	785	10.46	0.350	"
15	"	0.174	622.5	3.703	2301	30.34	78.13	31.0	9.70	758	10.10	0.332	"
16	"	0.174	622.5	3.725	2315	30.87	83.13	28.1	8.80	732	9.75	0.315	"
17	"	0.174	622.5	3.730	2322	30.96	88.13	26.85	8.32	733	9.77	0.316	"
18	"	0.174	622.5	3.750	2219	26.92	93.13	21.7	6.80	667	8.89	0.296	"
19	0.090	0.262	1156.	3.224	3727	49.69	35.	75.0	23.26	814	10.85	0.218	0.926
20	"	0.253	1087.	3.199	3479	46.38	50.	69.0	21.60	1080	14.40	0.311	0.926
21	"	0.254	1101.	3.208	3432	47.09	60.	65.0	20.36	1221	16.28	0.346	0.877
22	"	0.250	1071.	3.210	3438	45.84	70.	61.6	19.30	1351	18.01	0.392	0.875
23	"	0.250	1071.	3.196	3420	45.60	80.	59.2	18.55	1484	19.78	0.432	0.874
24	"	0.250	1071.	3.177	3417	45.33	90.	56.0	17.52	1577	21.02	0.462	0.875
25	"	0.245	1036.	3.190	3305	44.06	100.	52.0	16.29	1629	21.72	0.492	0.875
26	"	0.241	1016.	3.190	3241	43.21	110.	49.2	15.42	1696	22.61	0.523	0.865
27	"	0.241	1016.	3.207	3250	43.44	120.	45.25	14.19	1703	22.70	0.524	0.870
28	"	0.241	1016.	3.207	3258	43.44	130.	41.0	12.82	1667	22.22	0.512	0.870
29	"	0.240	1008.	3.215	3236	43.15	140.	37.2	11.64	1630	21.72	0.504	0.875
30	"	0.240	1008.	3.225	3244	43.25	150.	35.0	10.95	1643	21.90	0.506	0.875
31	"	0.236	971.	3.265	3162	42.16	160.	32.5	10.26	1642	21.88	0.520	0.865
32	"	0.236	971.	3.305	3209	42.78	170.	29.5	9.25	1573	20.96	0.490	0.865
33	"	0.237	976.	3.295	3190	42.53	180.	27.5	8.61	1550	20.66	0.485	0.865
34	0.150	0.354	1881.	3.164	5952	79.36	20.	99.5	31.10	622	8.29	0.105	0.960
35	"	0.349	1786.	3.164	5648	75.30	40.	92.0	29.10	1164	15.52	0.205	0.960
36	"	0.345	1781.	3.150	5543	73.90	60.	90.0	28.15	1689	22.52	0.305	0.960
37	"	0.343	1751.	3.153	5513	73.50	80.	83.5	26.10	2088	27.84	0.378	0.940
38	"	0.342	1747.	3.110	5433	72.44	100.	78.5	24.55	2455	32.73	0.453	0.953
39	"	0.337	1766.	3.070	5424	72.32	120.	73.0	28.05	3366	44.88	0.621	0.965
40	"	0.331	1666.	3.070	5124	68.32	140.	69.0	21.60	3024	40.32	0.591	0.965
41	"	0.326	1641.	3.075	5046	67.28	160.	63.0	19.70	3152	42.03	0.624	0.965
42	"	0.322	1586.	3.035	4731	63.08	180.	58.25	18.25	3285	43.80	0.696	0.965
43	"	0.320	1576.	3.085	4863	64.84	200.	52.0	16.29	3258	43.44	0.671	0.955
44	"	0.318	1561.	3.085	4816	64.21	220.	48.0	15.01	3302	44.03	0.685	0.955
45	"	0.317	1526.	3.085	4703	62.70	240.	44.0	13.79	3172	42.28	0.675	0.855

Experiments at Müllbach—Continued.

Number of the experiments.	Lift of the Sluice-gate.	Depth of water on the sill of the Waste-board, 5.014 m. in breadth.	Weight of Water expended in one second.	Total Fall.	Absolute Power expended by the Motor. No. kilogrammes lifted one metre in one second.	Absolute Power expended by the Motor. No. Horses-power.	Load of the Brake.	Number of Turns of the Wheel in one minute.	Velocity which the point of suspension of the load tended to take in 1 second.	Useful Effect measured by the Brake, or quantity of available Power. No. kilogrammes lifted one metre in one second.	Useful Effect measured by the Brake, or quantity of available Power. No. Horses-power.	Ratio of Useful Effect measured by the Brake, to the total power of the Motor.	Depth the Turbine was immersed, measured above the lower ring.
	Mtrs	Mtrs	Kilog.	Mtrs	Kilog.	Hrs. pr.	Kilog.	No.	Mtrs.	Kilo.	Hrs. pr.		Mtrs.
46	0.150	0.331	1652.	3.380	5583	74·44	260.	45.3	14.20	3692	49.22	0.662	0.865
47	"	0.313	1528.	3.272	5000	66.66	280.	38.0	11.89	3329	44.38	0.666	0.850
48	"	0.313	1528.	3.400	5187	69.16	280.	38.5	12.05	3374	44.98	0.651	0.950
49	"	0.313	1528.	3.405	5192	69.22	300.	34.4	10.79	3337	43.16	0.626	0.820
50	0.200	0.380	2053.	3.020	5857	78.09	10.	104.	32.55	326	4.34	0.055	0.890
51	"	0.377	2033.	3.045	6186	82.48	20.	103.	32.25	645	8.60	0.104	0.890
52	"	0.375	2025.	3.080	6237	83.16	40.	101.5	31.75	1270	16.93	0.203	0.890
53	"	0.373	2003	3.120	6256	83.41	60.	95.	29.70	1782	23.76	0.280	0.890
54	"	0.371	1993.	3.170	6332	84.42	80.	90.4	28.25	2260	30.13	0.357	0.890
55	"	0.371	1993.	3.190	6357	84.76	100.	87.1	27.15	2715	36.20	0.426	0.885
56	"	0.365	1951.	3.203	6249	83.32	120.	82.8	25.90	3108	41.44	0.496	0.885
57	"	0.361	1913.	3.240	6198	82.64	140.	80.	25.00	3500	46.66	0.565	0.885
58	"	0.361	1913.	3.255	6227	83.02	160.	75.	23.48	3757	50.09	0.604	0.885
59	"	0.361	1913.	3.270	6255	83.40	180.	70.	21.96	3942	52.56	0.632	0.880
60	"	0.361	1913.	3.305	6313	84.17	200.	67.6	21.16	4232	56.42	0.671	0.880
61	"	0.361	1913.	3.310	6331	84.41	200.	67.1	21.90	4200	56.00	0.664	0.870
62	"	0.353	1872.	3.310	6182	82.42	220.	63.	19·70	4334	57.78	0.702	0.870
63	"	0.353	1872.	3.335	6228	83.04	240.	58.	18.15	4356	58.08	0.700	0.870
64	"	0.349	1812.	3.306	5991	79.88	260.	50.6	15.84	4118	54.91	0.686	0.884
65	"	0.349	1812.	3.286	5960	79.46	280.	48.5	15.16	4245	56.59	0.712	0.884
66	"	0.349	1812.	3.321	6017	80.23	300.	44.	13.79	4137	55.16	0.690	0.884
67	"	0.392	2173.	3.610	7860	104.80	90.	100.	31.25	2813	37.50	0.357	0.640
68	"	0.383	2082.	3.650	7615	101.53	110.	97.	30.30	3339	44.51	0.440	0.640
69	"	0.388	2143.	3.560	7643	101.90	130.	91.	28.50	3705	49.40	0.485	0.640
70	"	0.384	2083.	3.475	7253	96.70	150.	87.	27.20	4080	54.40	0.562	0.680
71	"	0.378	2061.	3.300	6815	90.87	170.	80.	25.03	4255	76.70	0.626	0.680
72	"	0.371	1983.	3.250	6458	86.11	190.	72.	22.60	4312	57.79	0.670	0.680
73	"	0.367	1943.	3.230	6289	83.85	210.	67.	20.90	4389	58.52	0.700	0.680
74	"	0.364	1933.	3.358	6505	86.73	230.	62.1	19.43	4379	58.38	0.676	0.557
75	"	0.360	1908.	3.343	6392	85.23	240.	57.5	18.00	4500	60.00	0.703	0.557
76	"	0.356	1863.	3.392	6317	84.23	270.	54.	16.90	4563	60.84	0.721	0.557
77	"	0.356	1863.	3.398	6337	84.49	290.	49.4	15.46	4483	59.77	0.785	0.557
78	0.270	0.432	2523.	3.290	7562	100.82	170.	90.6	28.19	4592	61.22	0.609	0.750
79	"	0.432	2523.	3.070	7758	103.44	190.	87.	27.20	5168	68.90	0.670	0.750
80	"	0.422	2442.	3.170	7760	103.47	210.	84.6	27.5	5565	74.20	0.721	0.750
81	"	0.422	2442.	3.180	7750	103.33	250.	77.25	24.20	6050	80.66	0.785	0.750
82	"	0.422	2442.	3.310	8097	107.96	290.	69.	26.50	6264	83.52	0.760	0.720
83	"	0.432	2523.	3.475	8776	117.01	330.	66.1	27.20	6831	91.08	.707	0.720
84	"	0.423	2445.	3.390	8302	110.69	340.	61.5	8.19	6545	87.26	0.793	0.720

XXII.

Graphic representation and discussion of the results contained in the preceding Table.

To examine and unite the results contained in this table, we have the same as for the experiments on the turbine of Moussay, constructed curves having for abscisses the number of turns of the wheel in one minute, and for ordinates the ratio of the useful effect, to the total power of the motor.

The curve, Fig. 4, Plate I, relating to the series where the lift of the sluice-gate was (0.050 m.) $\frac{16}{100}$ of a foot, shows that, for this small lift, the useful effect rose only to 0.37 of the total power of the motor, and that from the velocity of 33 turns in a minute, to that of 51 turns, it was comprised between 0.35 and 0.37, so that between these wide limits, it varied but $\frac{1}{36}$th of its mean value.

The curve, Fig. 5, Plate I, relating to the series where the lift of the sluice-gate was (0.090 m.) $\frac{29}{100}$ of a foot, shows that the useful effect rose in this series to 0.725 of the total power of the motor, and that from the velocity of 26 turns in a minute, up to that of 55 turns, it was always comprised between 0.680 and 0.725, so that between these wide limits, it did not vary more than $\frac{1}{32}$nd of its mean value, 0.702.

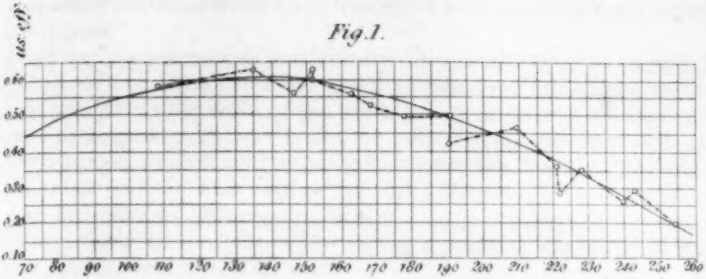
The curve, Fig. 6, Plate I, relating to the series where the lift of the sluice-gate was (0.150 m.) $\frac{49}{100}$ of a foot, shows that the useful effect rose, in this series, to 0.690 of the total power of the motor, and that, from the velocity of 35 turns in a minute, to that of 65 turns, the useful effect was always comprised between 0.630 and 0.690, so that between these wide limits, it did not vary more than $\frac{1}{32}$nd of its mean value, 0.660.

The two curves, Fig. 7, Plate II, relating to the series where the lift of the sluice-gate was (0.200 m.) $\frac{65}{100}$ of a foot, refer, the lower one, to the series where the turbine was submerged (0.88 m.) $2\frac{89}{100}$ feet, and the upper one, to the series where it was so, but (0.64 m.) $2\frac{10}{100}$ feet. Their examination shows that, even to the velocity of 60 turns in a minute, the ratio of the useful effect to the total power of the motor, is the same for the two series, and rises for the case of the maximum to 0.710. We see further, that for the first series, from the velocity of 40 turns in a minute, up to that of 66 turns, this ratio has been constantly comprised between 0.675 and 0.710; so that even between these wide limits, it did not vary more than $\frac{1}{39}$th of its mean value, 0.692.

For the second case where the wheel was submerged only (0.64 m.) $2\frac{10}{100}$ feet, the ratio of the useful effect, to the total power of the motor, diminished less rapidly in proportion as the velocity augmented, and it remained comprised between the same limits of 0.675 to 0.710, from the velocity of 40 turns in a minute, to that of 72½ in a minute.

The curve, Fig. 8, Plate II, relating to the series where the lift of the sluice-gate, was (0.270 m.) $\frac{88}{100}$ of a foot, shows that the ratio of the useful effect, to the absolute power of the motor, was, at the maximum, 0.79, and that from the velocity of 55 turns in a minute, to

Fig. 1.



1st Series. 2nd Series.

Fig. 2.

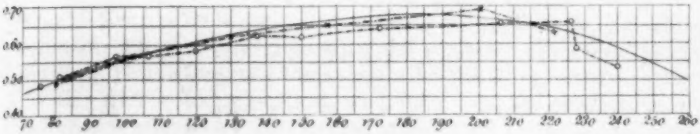


Fig. 3.

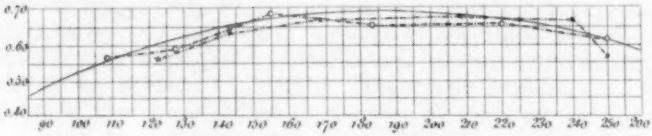


Fig. 4.

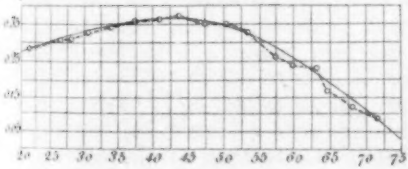


Fig. 5.

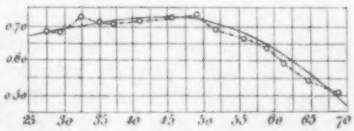
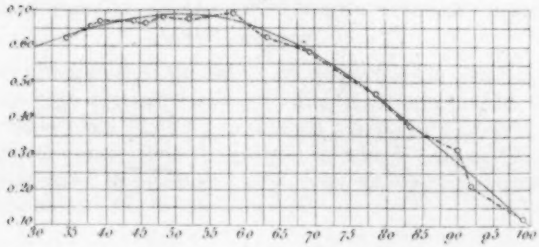


Fig 6



that of 79 turns, it was always comprised between 0.775 and 0.790; so that even between these wide limits, it varied only $\frac{1}{77}$th of its mean value, 0.780.

After having examined particularly the results relative to each of the series of experiments, if we cast a glance over the whole, we see immediately that the ratio of the useful effect, measured by the brake, to the total power of the motor, is only 0.37 at the maximum for the first series, a result much inferior to those we had obtained for it in the other series. For explaining this difference, it appears to me proper to relate an observation, which I have had occasion to make, on the introduction of the water along a curved bucket of a form analogous to those of the turbines.

When we introduce by the outer border of a curved bucket, carried in its movement of rotation about a vertical axis, a filament of water possessing a certain velocity, as soon as the liquid reaches the surface of the buckets its velocity is altered, not only by the action of the centrifugal force which tends to remove it from the axis, but also by the adhesion which it contracts with the surface. The fluid vein becoming thin, rises along the bucket to a height the greater in proportion to the first velocity; it follows hence, that the relative velocity of the liquid is altered by two causes, and that a considerable portion of the active force of the liquid is consumed by its adhesion to the partition: moreover, if, as in the turbines, the buckets are short, and little raised, a part of the liquid can lose another portion of its velocity against the upper ring, whilst the other part, actuated by an ascending velocity, escapes to the outside, preserving a vertical velocity which it would not have acquired, if the buckets had not had a height equal to that of the filament of water. This shows besides, that the diminution of the useful effect in the case of small lifts of the sluice-gate, belongs to circumstances of this species, because we see the useful effect increases in proportion as the difference between the lift of the gate and the height of the turbine diminishes.

In effect, as soon as the height of the sluice-gate reaches (0.09 m.) $\frac{29}{100}$ of a foot, the useful effect becomes equal to about 0.71 of the total power of the motor, and for the stronger lifts which come near the height of the wheel, it reaches the value of 0.79 of the total power. The experiments, moreover, showed that for the discharges (of water) which varied from 1500 to 2500 kilogrammes in one second, the ratio of the useful effect, to the absolute power of the motor, is sensibly the same within these wide limits.

XXIII.

Observations relative to the experiments when the wheel was submerged.

We shall observe that the series of experiments relative to the lift of the sluice-gate of (0.200 m.) $\frac{66}{100}$ of a foot, where the wheel was only immersed from (0.64 m. to 0.56 m.) $2\frac{10}{100}$ to $1\frac{84}{100}$ feet, had given results more advantageous than those in which the depth of immersion was increased to (0.88 m.) $2\frac{89}{100}$ feet, as soon as the velocity had

exceeded 60 to 65 turns in a minute. This effect ought, without doubt, to be attributed to this, that, in the second case, the mass of water to which the wheel communicated a gyratory movement, was greater than in the first, and, that the rubbing surface of the buckets was submitted to a greater pressure; but the velocity of the wheel, suitable to the maximum of effect, being comprised between 45 and 65 turns in a minute, it follows that within the common limits of these velocities, this difference in the depth of immersion has no important influence on the useful effect.

The last series of experiments, relative to a lift of the sluice-gate of (0.270 m.) $\frac{88}{100}$ of a foot, has given us a useful effect at the maximum of 91 horses, although the wheel had been constructed only for 45 to 50 horses, and we regretted not being able to push the experiments further, by increasing the load on the brake; but the cast-iron shaft of the turbine, having been proportioned only for a power of 40 to 45 horses, at a velocity of 50 to 60 turns in a minute; after having nearly doubled the load which it was meant to carry, we had not the courage to go further, from the fear of occasioning some permanent twist.

XXIV.

Conclusions from these Experiments.

1. That the turbine of the power-weaving establishment of Müllbach, which was only about (2 m.) $6\frac{56}{100}$ feet diameter, and (0.333 m.) $1\frac{09}{100}$ feet in height, could, under a fall of from (3.50 m. to 3.75 m.) $11\frac{48}{100}$ feet to $12\frac{30}{100}$ feet, expend a volume of water $88\frac{3}{10}$ cubic feet, or 2.5 cubic metres in a second, transmitting, then, *a useful effect, or available power, of* 91 *horses.*

2. That, at a velocity of 50 to 60 turns in a minute, and with a strong lift of sluice-gate, it rendered in *useful effect*, 0.78 *of the total power expended by the motor.*

3. That the velocity of the wheel could vary within very wide limits without the useful effect abating more than from $\frac{1}{25}$ to $\frac{1}{30}$ of its maximum value.

4. That the ratio of the useful effect, to the total power of the motor, did not diminishwhen the wheel was immersed about (1 m.) $3\frac{28}{100}$ feet, if it moved with a velocity not much exceeding that which belonged to the maximum of effect when it *was not* immersed.

5. That the expense of water having varied from 1500 to 2500 kilogrammes in a second, that is to say, in the ratio of 3 to 5, the ratio of the useful effect, to the total power, remained sensibly the same.

(To be continued.)

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

(Continued from Page 251.)

LECTURE XV.—WORKING EXPENSES OF RAILWAYS *(continued.)*

Having, in the last lecture, analyzed the working expenses of railways, in reference to the train, that is, reduced to a rate per train per

mile, with an average load at the usual velocity, the Professor considered it might be well to consider the same subject in another light. In the preceding mode of calculation, no regard was paid to the amount of what might be called the useful weight carried. It seemed to the Professor, that the proportion between the dead weight of the engine, tender, and carriages, and the weight of the passengers and their luggage—in short, between the unprofitable and the profitable load—formed an important element for consideration, even if it did not affect the principle on which railways ought to be worked. In the common omnibus, with a full complement of passengers, the proportion was one to one—taking the average load, about five to three—or, including the weight of the horses (the moving power which has also to carry itself), about three to one, or, with a full load of passengers, something less than two to one. But, on the railway, owing to the far greater weight of the carriages, and general arrangement on most lines, the proportion of dead weight is much greater. In a first class carriage, as adapted for long lines, and fully loaded with passengers and their luggage, the proportion is two and a half to one; but, taking the average load, it is about four to one, and, when but little luggage is taken, four and a half and five to one. On short lines, where the trains run often, with many carriages, the proportion is sometimes as high as eight to one, or, including engine and tender, as twelve to one. In an ordinary train of about seven carriages, their weight, and that of the engine and tender, may be taken at about fifty tons; the average number of passengers, has, on a former occasion, been shown to be about sixty per train, or four tons without, and, perhaps, five tons with, their ordinary weight of luggage, and say one or two tons of packages and parcels paying freight, being a proportion of six or seven of unprofitable, to one of profitable load; and if the carriages were all full, about four and a half or five to one, as above, and, on the average, the proportion might very fairly be taken as at least five to one. It appeared to the Professor that there was some radical error here, and that some arrangements were wanting to reduce this proportion, as far as the carriages were concerned, for, of course, as long as the locomotive engine was used, its weight would always form a large proportion of the load, particularly with light trains—though the carriages certainly required to be made strong and heavy on this system—and this seemed an inherent defect on this principle of locomotion, perhaps quite irremedial. Yet, at all events, on many lines the proportion of dead weight of carriages was much too great, and might be remedied. Of late this had been done on the Greenwich Railway, where, by combining two classes of seats in the same vehicle, much fewer carriages sufficed. There was a great contrast to this on the Blackwall Railway, where, from having a separate carriage for each station, according to the peculiar mode of working that line, the proportion of dead carriage weight was generally about three, and often four, times as much as on the Greenwich, though the carriages were of the same build. Owing to this and to other causes, extra guards, rope, &c., notwithstanding the generally admitted economy of stationary power, the expense of working the Blackwall Rail-

way, per train per mile, was double what the Professor found was the average for the working on several locomotive lines, and quite as high, if not higher, than the present rate of working on the Brighton Railway, which was the highest of any that had yet come under his cognizance. Although, abstractedly, this over proportion of dead weight carried, was not always connected with the moving power, yet an engineer ought to point out, and, when within his control, to remedy such an evil, as the loss consequent on carrying useless weight is equivalent to that arising from increased resistance of gravity in surmounting an unnecessary ascent—a case which every engineer is naturally anxious to avoid.

In the mode of reducing railway expenses to a mileage, adopted in the last lecture, the number of passengers, and their proportion to dead weight of carriages, had not been considered, for it was clear that the arrangement of carriages in any train being supposed to be duly proportioned to the average traffic, any addition to the average assumed load would be pure profit, and would not cause any sensible addition to the cost of the transit of the regular load, for which all the necessary arrangements of engines, tenders, carriages, guards, stations, and the whole working and carrying establishment of the railway was already provided and paid for. But, suppose another mode of considering the working expenses be adopted, viz., from the number of passengers in a train, deduced from an average of many lines for several years, or from any assumed number per train, let the cost per passenger per mile be worked out, and this will lead to the consideration of the true policy for attracting the greatest number of persons, and trying to fill the trains up, as they must go, at any rate.

The Professor then went through the various items of railway expenses stated in the former lecture, and brought them out in decimals of a penny per passenger per mile—the result being, that, taking account of experience gained and applied, and economical arrangements duly introduced, the expense of locomotive power might be taken at ¼*d.* per passenger per mile, which was coming back to the original estimate made for the working of the London and Birmingham Railway. Other expenses, including government duty, would bring the total up to two-thirds of a penny, and, under favorable circumstances, of well filled carriages, this might sometimes be brought down to ½*d.*, but taking the average of lines as now worked, the cost was about 1*d.* per passenger per mile. On many of the American railways the cost was as low as ½*d.*, and for long lines on the continent, in India, &c., where wages were low, and coal or wood might be got very cheap for locomotive fuel, and no rates, or taxes, on profits and passengers were laid, the charge of carrying passengers per mile might be fairly taken at ½*d.* only. Now, if the proportion between the unprofitable and the profitable parts of the load were reduced to three to one, as regarded carriages only, and six to one as regards the whole weight of the train, the expense of carrying passengers, taken by weight, will be still at least three times as expensive as carrying goods only at the same velocity, the proportion being of wagons to goods as two to three, and of the whole train, including engine and tender,

at less than two to one, and with heavy trains, of goods only, about one to one, and for coal and mineral traffic, at diminished rates of traveling, still less. The Professor observed, that the cost of conveying merchandize might be taken at about 1*d.* per ton per mile for railway expenses only, exclusive of collection and distribution at the termini of lines, and that of coal and minerals at about ½*d.* per ton per mile. With these elements, therefore, of the expense of working railways either per train, or per passenger, or per ton, it is for the politic manager of a public concern to consider what should be the rate of charges above these cost prices to make to the public, so as to induce the greatest amount of traffic. Mr. Vignoles then observed, that there was a third way of considering the subject of the working expenses of railways, in reference to the number of engines employed, which was the mode adopted by the Irish Railway Commissioners, and which was, perhaps, the proper way of calculating the annual cost on lines of little intercourse, on which, however small the traffic might turn out to be, yet a certain number of engines must be kept to do any work at all. The commissioners in following out this inquiry, endeavored to determine the proportion the cost of locomotive power bore to the total working cost of a railway. For the Liverpool and Manchester line it was found that this proportion was only one-fourth the gross annual charges on that line, including much town carriage of goods collected and delivered; but on the Dublin and Kingstown Railway the proportion was, at that time, nearly one-half. It was observed by the Professor, in a digression, that for the average of railways it was now determined to be about one-third. The commissioners finally assumed the cost of locomotive power to be one-third of the total expense of working a line of mixed traffic, and that to run a given number of trains per day, a certain number of engines must be provided; it was then calculated that £1750 a year would be the cost of each engine to work about from 25,000 to 30,000 miles annually, and then they computed the amount of gross receipts necessary to cover those expenses and interest of capital. This was working backwards, to ascertain whether it is justifiable to make a railway at all in certain districts. The result of the commissioners' calculations were, that, supposing there went only two trains daily throughout a given line, the average load of each train ought to consist of either fifty tons of goods, or eighty passengers, or a mixed load of twenty-five tons of goods and forty passengers, or, in that proportion, in order to justify a line being made—the average charge for passengers being assumed each 1½*d.*, or for goods 2*d.* per ton per mile, which, it may be observed, is scarcely the half of the average rates of charge on the principal English railways. Mr. Vignoles observed, in conclusion, that having shown that the cost of conveyance of passengers, merchandize, minerals, &c., could be nicely calculated from the experience gained, and could be brought to the definite mileage rates before mentioned, *he thought the proper railway charge should be double the cost for working;* which, when the railways had been judiciously constructed, and without extravagance, would sufficiently remunerate

the undertakers, as such moderate principle of charging would bring the most traffic.

(To be continued.)

Great Britain Steamer.

By the politeness and favor of Mr. Guppy, the Engineer of the Company, we were permitted to inspect this celebrated vessel on Tuesday, the day previous to His Royal Highness Prince Albert's visit.

It is impossible for us, by any description we can give, to do justice to this great and noble ship. To form a true estimate of her, one must see her, go on board of her, and compare her with other vessels. Her upper deck, which is 308 feet long, and 50 wide, and flush throughout its entire length, appears to be a promenade, of which it would require some effort to march from one end to the other. From the figure-head to the taffrail is 322 feet.

Her grand saloon aft, is a noble room, 98 feet by 32, and near 8½ feet high. The fittings of this room are different from those of any other steamer we have yet seen. The style is extremely neat and chaste. About 8 feet from each side, and also in the centre line of the ship, are a row of pillars, some 10 or 12 feet apart, and opposite to each of these is a pilaster very tastefully ornamented, the intermediate spaces being panelled, so as to throw out the ornamented pilasters to the greatest advantage. At the ends and certain angles of the room, are placed mirrors, at such angles as to produce very pleasing illusions, and to have a fine effect.

Above this is the principal promenade saloon, which is decorated to correspond, and which also has a row of pillars down its centre. Ranged along its sides are seats for those who choose to lounge and sit, while the middle forms a light and spacious promenade in wet, or rough, weather.

In the fore part is another promenade cabin, or saloon, of less dimensions, being 67 by 21¾ feet, but intended, we hear, to be fitted up in a similar manner.

Beneath this, above the water-line, is the fore dining-room, which is 61 by 21¾ feet. There are 26 single bedded-rooms, and 113 double bedded.

For the accommodation of ladies there are large and commodious sitting-rooms communicating with their berths. These rooms, to the capacious size of which several berths are necessarily sacrificed, will be a great comfort to lady passengers, particularly in rough and foul weather.

We understand that the number of passengers' beds will be about 260. They might easily have made up a great many more, but have chosen to limit the number, rather than to encroach upon the comforts and pleasure of their customers, of which, indeed, they have been more prodigal than they might, with a just regard to their own profit.

The public has long been informed, that this vessel is to be driven by a propeller somewhat upon the principle of the screw. The plane

of this propeller is at right angles to its shaft, which is about 8 or 9 feet above, and parallel to the keel. To speak popularly, it consists of four segments of fans, (frustrums of the screw spiral of 22 feet pitch) not plain, but twisted, so as to produce the best effect upon the water, the general plane of each being inclined in an angle to the plane of the propeller. The form, inclination, or pitch, and dimensions of the fans, we understand have been the result of long and careful experiment, made for the especial purpose of finding out the best form.

The diameter of the propeller is 16 feet, and its top will be under the water line when the vessel is loaded.

By dividing the propeller into four parts, it is calculated that the motion of the vessel will be easier, and that the water will not be so much sliced, as if there were a greater number of fans, and will hence be capable of offering more resistance.

The shaft of the propeller, which is of solid wrought-iron, 16 inches diameter, passes through a stuffing-box in the stern of the vessel, and terminates in a wheel, which is to be driven, as we understand, by a pitch chain passing over this and the great drum. This wheel is 6 feet, and the drum attached to the crank shaft of the engine is 18 feet diameter. The propeller, therefore, makes three revolutions for every revolution of the drum, or every double stroke of the engine.

The length of the stroke is 72 inches, and the diameter of each cylinder 88.

There are four cylinders, two placed on each side of the vessel, opposite, or nearly so, to each other, the opposite pairs converging towards the top in an angle of about 68 degrees. The connecting rods of each pair are attached to the same crank, and, therefore, drive the crank as one cylinder.

This plan simplifies the machinery much, and obviates a difficulty which had been conceived by some eminent steam navigation gentlemen, with regard to the simultaneous working of the cylinders in a rough sea. As designed, the four work as one pair.

It is intended to work the cylinders expansively, with an apparatus for cutting off the steam at any part of the stroke within certain limits. The intention is to cut off at one-fourth, and expand the other three-fourths. The computation is, that when the cut off is at half stroke, each cylinder will do the duty of 250 horses, the steam in the boiler being 6 lbs. above the atmosphere. The engines are, therefore, collectively, of 1000 horse-power.

The boiler is 34 ft. long, 32 ft. broad, and 22 ft. high, and is divided into three nearly equal compartments, each compartment forming a separate boiler, and may be all three used separately, or together. These compartments add much to its strength. The steam-pipes from each compartment unite behind the boiler, and the steam-ways, 24 inches diameter, turn round the sides to the cylinders.

The boiler is heated by 24 fires, and its plates are 7-16th inch thick. The flues recurve within the boiler, and give it something of the property of a tubular boiler.

At present merely the boiler and cylinders are put in the vessel. The framing and truss-work for the shaft, &c., are of Demerara

Green Heart wood, and very thick wrought-iron, and present the appearance of great strength.

The rudder is 7 ft. wide, and works upon a pivot, of course, behind the propeller, two-thirds behind it and one-third before. It will, therefore, be very easily worked, and as the propeller will force the water back upon it with considerable force, it will possess great command over her motions, even at comparatively slow velocities. This is one great advantage the screw and all aft propellers have over paddles; the vessels are always more manageable with them.

At 6 lbs. per horse-power per hour, the *Great Britain* will consume 2.67 tons of coal per hour, or near 64 tons per day. To steam, therefore, for 20 days, she must carry 1,280 tons of coals. Her bunkers will contain 1,200 tons, or provision for about 19 days.

With regard to the vessel herself, she is, on all hands, allowed to possess the finest proportion, and most beautiful lines. Her neat entrance, clean run, and gracefully swelling sides, strike the eye as exceedingly well calculated for speed, steadiness of motion, and sitting well upon the water. From her great length, and apparently narrow beam, it might be expected she would be disposed to roll, but as her water line is below the swell of her sides, that will be a great check, and the probability is, that she will ride with greater safety, and be less liable to ship seas. She is calculated to average 12 knots an hour at the least, by steam, and with a good fair wind, 13 through the water. At this rate she will reach New York in 10 days.

It is intended to carry only one class of passengers, for which, as we said, every comfort and convenience are secured.

As our readers know, she is made of iron. Her plates and angle-irons, or those which would be called her ribs, are ⅝ths of an inch thick. These are trussed with immense stringing timbers at every deck and division, and strengthened by struts from the iron joists supporting the decks. The lower decks themselves consist of narrow planks stretching from side to side, of 5 inches thick. These are again strengthened by cross-iron stays, screwed to them in all possible directions beneath. In fact, every care appears to have been exhausted to ensure ample strength and stability to this magnificent vessel.

The displacement of the *Great Britain* is about 3,200 tons. Her power, therefore, is one horse to 3.2 tons, which is a high proportion, especially for a vessel of her tonnage. Taking, consequently, into account her tonnage and power, they are warranted in calculating upon an unusually high speed.

Her engines and machinery weigh about 600 tons, and the total quantity of iron used in her, is 1,500 tons. The greatest care has been used to have none but materials, whether iron, or wood, of the very best quality.

She has 6 masts, 4 of which carry fore and aft sails only, and the main-mast, which is 75 feet high above the deck, will have an immense spread of square and studding sails.

She has 5 water-tight bulkheads, all reaching above the water-line, but some of them much higher. Her funnel is 39 ft. high, and 8 ft. diameter.

The estimate was for £75,000, but it is expected she will cost about £100,000. The weight of the main-iron shaft is 16 tons, the largest ever constructed. It was manufactured at the Mersey Iron Works. Her boiler will contain about 200 tons of water; and her pumps, worked by machinery, will be able to throw off 7,000 gallons of water a minute.

At the time we were at Bristol, we had an opportunity of going over the Company's work-shops, and were both surprised and pleased to observe the unusually fine manner in which they turn out their work—it is a credit to Bristol.

Railway Magazine.

The Steam Excavating Machine.

We have already had the pleasure of introducing this important machine to the public, and we now avail ourselves of the opportunity of giving some further account of it. As is well known, it is of American invention: and this individual machine was imported from the United States, after having been employed on a railway there for the purpose of testing its capabilities in this country. It is now at work on the Eastern Counties Railway, about 20 mile from London, and is exciting much attention. In its present state, the machine is rather complicated, but it is susceptible of great improvement; and we have no doubt that any machines manufactured in this country will be much simplified. For this purpose it cannot be in better hands, the management of the patent being entrusted to Mr. John Braithwaite, the engineer, whose mechanical attainments are well known to the public, and who is well qualified to turn a machine of this kind to the best account.

The accompanying engraving* is a perspective view of the machine when at work, and it will be seen by it, that one man, the engine-tender, stands behind, to regulate the performance of the engine, and another man in front, to regulate the motion of the scoops, and to turn the jib, or crane, to the right or left, as may be required. By the aid of this jib, the scoop is enabled to take a sweep of 30 feet, and clear away obstructions before it to the height of about 14 feet.

The cubic content of the scoop is 1½ yard, and it lifts about 1¼ cubic yard, two of which is about a wagon load of 2½ cubic yards. If the wagons were brought up as fast as the machine could supply them, it would fill 30 per hour. During the day we inspected the machine, it loaded 26 wagons of 2½ cubic yards each within the hour; and at another performance, it filled 103 cars in 5½ hours. By these trials, the duty of the machine appeared to be, upon an average, 20 wagons, or 50 yards, per hour, or 500 yards per day. This quantity does not appear to be more than half the duty of the machine, as detailed in a report before us, emanating from a committee of managers of the American Institute, New York, especially appointed to examine the machine. The committee state—

* See engraving in this Journal, page 324, vol. v.

"The excavator has been employed for three years upon the Western Railroad, and other places, and that this test showed an immense saving of expense. It is calculated to do the work of 150 men, and will fill cars as fast as they can be presented to receive their loads. Allowing for stoppages, one minute may be given as the average for filling a car of 1¼ cubic yard. The interest for the cost of the machine, wear and tear, men's wages, fuel and oil, 13¼ dollars, (about 2*l.* 16*s.*) but to cover the contingencies, say 20 dollars."

There is also another report, showing the daily performance of two machines employed for two months, in almost constant work, at Brooklyn, New York, during which period the two machines worked collectively 881 hours, and excavated and loaded 92,593 cubic yards of earth, equal to 105 cubic yards per hour, or 1080 cubic yards per day. The machines worked during the above period, upon an average, nearly ten hours per day, which is equal to the working hours of a man. The quantity which one navigator can remove, or "get and fill," in one day, is about ten cubic yards, or one cubic yard per hour; we have, therefore, the performance of one machine equal to 105 men, according to the statements of the American engineers.

We will now proceed to examine the comparative cost of working by the machine and manual labor. For this purpose we must calculate the power of the engine, which is called a 10 horse engine, but on account of the high pressure at which the steam is worked, it will be found equal to 34 horse effective piston power. The following are the particulars of the engine:

Diameter of cylinder 9 inches = 63.6 square inches.
Length of stroke, 1 foot; number of strokes per minute, 100 to 110—say 200 feet per minute.
Pressure of steam, 90 to 100 lbs, per square inch—say 90 lbs.
Fuel—coke.

Then we shall have the engine-power $= \frac{63.6 \times 200 \times 90}{33{,}000} = 34.7$ horse-power on the piston, which, if taken in the same proportion as low condensing engines, the nominal power of which is taken at only 7 lbs. pressure, or about half the effective piston-power, we shall have the nominal power of the engine equal to 17 horses, the consumption of which may be taken at about 10 lbs. of coal, or 8 lbs. of good coke, per horse per hour, which will give, for the consumption of the above engine, $17 \times 8 = 136$ lbs. per hour, or 12 cwt. per day of 10 hours. If we take the cost of the coke at 35*s.* per ton, delivered at the works, we shall have the cost of the fuel 21*s.*, then the cost of working the machine per day may be stated thus:—

	s.	d.
Coke, - - - - - -	21	0
Oil, tallow, &c., - - -	2	0
Engine tender, - - -	6	0
Man on the stage, - - -	5	0
1 laborer assisting, - - -	3	6
Sundries, - - - -	2	0
Cost per day, - -	40	0

This will be the cost for removing 500 cubic yards of earth, but exclusive of repairs, depreciation, interest on cost of machine. The cost of making one of the machines we estimate at 1200*l.* The cost of manual labor may be taken for "getting and filling," (see Journal vol. v, p. 187,) at 4½*d.* per cubic yard, then,

500 cubic yards at 4½*d.* = 9*l.* 7*s.* 6*d.*

We have here a difference of 7*l.* 7*s.* 6*d.* between the cost of engine and manual power; and if we make an allowance for the repairs of the machine, depreciation, interest, &c., 2*l.* per day, there will be a saving of 5*l.* 7*s.* 6*d.* We may, therefore, set down the actual cost of engine power at 2*d.* per yard, which would give 4*l.* 3*s.* 4*d.* per day, for 500 yards, thus clearly showing that the steam excavator must ultimately supersede manual labor, on account of its cost and rapidity in execution for all extensive cuttings, either for railways, canals, or docks; but if we make our calculations according to the report of the American engineers, allowing the duty of the machine to be 1050 cubic yards per day, the calculation will stand thus:—

	£	s.	d.
1050 cubic yards by manual labor at 4½*d.*	19	13	9
Deduct—working of engine per day 2*l.*, Repairs, depreciation, interest, &c., 2*l.*	4	0	0
Saving, - - -	15	13	9

By this calculation the cost of excavation is not quite 1*d.* per yard.*

Civ. Eng. & Arch. Journ.

Woolen Factory for Turkey.

Mr. Fairbairn exhibited a model, showing the plans, sections, and architectural elevation of a Woolen Factory, to be constructed of cast and wrought iron, near the town of Izmet (Turkey) for the Sublime Porte.

Mr. Fairbairn said that, in 1839, he visited Constantinople under the instructions of the late Sultan Mahomed, and reported upon nearly all the government works. Their extension was checked by the death of that prince, but the present Sultan was disposed to carry

* The above article is accompanied by letters from Mr. Whistler, the chief, and Mr. Swift, a resident, engineer, on the Western Railroad, in Massachusetts, during its construction, who speak very favorably of the actual working of these machines, in some heavy earth cuttings, on that railway, *during three years.*

Mr. Swift states, that upon one of the sections, "it excavated 19,000 cubic yards (of sand and gravel) in twenty-five working days, and 1000 yards per day were excavated for several days in succession."—Com. Pub.

them into effect, and, by his orders, Mr. Ohanes Dadian had arrived in England, in furtherance of the plans for ameliorating the state of the Turkish community, by introducing useful arts and manufactures, in which he was aided by his Excellency Ali Effindi, the ambassador to the court of England, and the consul-general, Mr. Edward Zohrab. Almost all the houses, and many of the public buildings, in Turkey, being constructed of timber, destructive fires were frequent. In many parts of the country the common building materials were expensive; iron had, therefore, been resorted to for construction, and Mr. Fairbairn had already sent over an iron house for a corn-mill, 50 ft. long, 25 ft. wide, of three stories in height, and with an iron roof. It was finished in 1840, and erected at Constantinople in the succeeding year. The success of this attempt induced a second order, which was for an extensive woolen factory, to be composed entirely of cast-iron plates, the interior being formed throughout of brick arches, upon cast-iron columns and bearers, with an iron roof. He then described in detail, the construction of the different parts of the building, and the machinery, which would be driven by a fall of water of 25 ft. in height, of the computed average power of 180 horses. Several ingenious devices were described for preventing any objectionable effects from the high conducting power of the metal. The piers between the windows were hollow, so as to admit a current of air through during the hot season; and the iron roofs were so arranged as to have beneath them a coating of plaster, to serve as a non-conducting substance. The two principal rooms were described to be 272 ft. long, 40 ft. wide, and 20 ft. high; and 280 ft. long, 20 ft. wide, and 20 ft. high; with a great number of other rooms, for the several processes in the manufacture of coarse woolen cloths, for the counting-houses, and departments of the directors, and for the reception of the sultan, &c. The area of the enclosed surface, including the court-yard and buildings, was nearly 3 acres, or 110,621 square feet.

The floor surface in the basement rooms = 16,480 square feet. Ditto in the upper rooms = 54,616 square feet. Ibid.

Legal Decision regarding Well-Sinking.

In the Court of Exchequer Chamber in Error, on Wednesday, May 19, a judgment of considerable importance was pronounced by Lord Chief Justice Tindal, in the case of "Acton *vs.* Blundell." Within twenty years before the commencement of the action, the plaintiff had sunk a well, and the water which it collected was sufficient to work his mill; but in 1837, the defendant dug a coal-pit three-quarters of a mile distant, which, eventually, drained the well dry, and, therefore, an action was brought to recover compensation. On the trial, the judge told the jury, that if the defendant had dug the pit in the manner which was usual in working and winding a mine, he was justified by law in what he had done; and the jury found for the defendant. A bill of exceptions to this charge was presented, which

had, subsequently, been argued, but the Court now decided that the summing up was correct. The Court were of opinion that the case should be decided on the principle of the rule which gave to the owner of the soil every thing under the surface of it; and that if the plaintiff had suffered loss by the exercise of the defendant's rights, it was a loss which was *damnosum non injuriosum*, and for which no action could be maintained. The Court, therefore, unanimously gave judgment for the defendant. Ibid.

On a New Application of Railways. By Ellwood Morris, C. E.

It is well known that prior to the introduction of the modern railway system, cities were chiefly furnished with provisions, from a space covered by the revolution of a very limited radius, whose length was determined by the distance which horses could travel within a few hours; while but very moderate supplies, indeed, were ever drawn from a greater distance than a day's drive.

An immediate result of the greatly augmented speed of travel, consequent upon the construction of any modern railway leading from a city into the interior of the country, is a direct and considerable extension of the surface, capable of becoming with advantage, *tributary to the market of that city.*

The large augmentation of the surface of production, tributary to any market consequent upon a diminished cost and increased speed of transport, must, inevitably, have an effect upon the value of provisions there, and it will follow, hence, that whenever the railway system shall be properly availed of, for the supply of our cities, the selling prices of country produce in their markets *must fall*, and their numerous inhabitants be thereby benefitted.

This is but another phase of the important economical revolution which the great iron roads of modern days are gradually producing in all that is, in any way, dependent upon the cost, or time, of carriage.

Upon the European railways the highest advantages seem to have been derived from the facilities they furnish for the cheap and easy carriage, from great interior distances, of live stock, and other provisions, destined for the supply of the overgrown communities there assembled in the great cities.

Even in our own country their influence, in the aspect referred to, is beginning to be strongly, as well as beneficially, felt, and one railroad corporation, at least, has profited considerably by the establishment of a market train, regularly drawn, like other freight, by locomotive steam power.

We refer to the Camden and Amboy Railroad Company, the directors of which, in their elaborate report of 1840, upon the completion of their works, describe the success that has attended the establishment of a regular market train upon their railway, which has been the

means of opening, for the supply of the provision market of New York, a large district of country, practically inaccessible before.

In the report referred to, at page 11, we find the following statement:—

"Two years since, at the request of some market people in New Jersey, a line, called *the pea line*, with two cars, was occasionally started from Camden to New York, with no other view, or expectation, than the accommodation of a very useful and respectable class of men. This line has steadily increased until it has become profitable beyond all expectation. During the past year it has been running daily, sometimes taking with it as many as sixteen cars, laden, at the appropriate season, with peas, peaches, potatoes, asparagus, cabbages, live stock, and upon one occasion, (as incredible as it may seem,) *thirty tons of green corn!*"

The European railroads have been found extremely beneficial in the transportation of live stock, and other provisions, to the great cities, which have thus been enabled to draw their supplies from a much larger surface of country, and, consequently, at a smaller price.

Since the completion of the Baltimore and Ohio Railroad to Cumberland, extravagantly high prices can no longer be commanded for agricultural products on sale in the Baltimore markets; thus with the article of *butter*, it has been recently observed, that whenever it becomes unusually high, large quantities are promptly sent down by the farmers beyond Harper's Ferry, and prices fall at once.

So strong, indeed, is the influence of this railway in regulating, and keeping down to a moderate standard, the market prices of Baltimore, that it has already become a subject of complaint with those, who, from the nearness of their position, have heretofore been able to hold a monopoly of the supply.

Other facts might readily be adduced, which, in connexion with the remarkable experience of the Camden and Amboy Company, would show, in a striking light, the advantages which must follow the introduction of market cars upon railways, and will, ultimately, among other results, tend to soften the prejudices still entertained, by some, against railways, as aristocratic monopolies, since, by reducing the cost of the necessaries of life to all, they will recommend themselves, in the strongest manner, to a large majority of our population.

With the introduction of market trains upon railways, *provision depots* become desirable, and the first of these which has fallen under the notice of the writer, where provisions brought in railway cars are kept on sale, both wholesale and retail, is that lately erected in the city of Philadelphia, in connexion with the Columbia Railroad, and opened in June of this year, under the denomination of the *car market*.

It is this new application of railways—*to the formation of a railroad market*—that it is proposed briefly to describe.

The idea of constructing a *railway market*, having been for some time entertained by Mr. Samuel Webb, an intelligent and enterprising citizen of Philadelphia, who foresaw the advantages that must flow from the transportation of provisions by the railways centering upon

that city; he applied to the writer during the past year, to work out the practical details, and superintend the construction of *a car market-house*, of which he furnished the outline.

This building has accordingly been erected: it was opened to the public in June last, and promises to be very successful.

The *car market* is 200 feet long, and 40 feet wide, it fronts on Schuylkill Seventh street, north of Callowhill, its axis being parallel to the State Railroad leading to Columbia, and 130 feet distant from the southern sideling.

In consequence of the position of the building, it was necessary to enter it through the north flank by reversed curves, with a short tangent between: this is effected by turning out of the Columbia Railway to the right, upon a curve of 80 feet radius, and 51½° deflection, into a tangent running off obliquely at that angle; thence by this tangent 90 feet, and then by another curve of 80 feet radius, and 51½° deflection, turning to the left we curve into the axis of the market-house.

Through the centre of this building longitudinally, from end to end, a straight track of railway is laid, and to enable the empty cars to pass out without interference, a return track is provided, which, by a radius of 48 feet turning 128½° of curvature, re-enters the oblique tangent before mentioned.

All of these curves are laid with a common railway superstructure, and, though their radii are so very limited, they, nevertheless, answer their purpose satisfactorily.

The writer will here observe in passing, that for the ordinary entrance tracks of depots, a common railway superstructure, where all the wheels run upon their treads as usual, will answer very well when curved upon a radius of 80 feet, and of the numerous side tracks recently laid here, to accommodate the coal trade descending the Reading Railway, nearly all the curves are ordinary railroad tracks, and in some of them radii of curvature of less than 80 feet, have been adopted without inconvenience.

The car market is near 37 feet wide in the clear, and the stalls are made to project out 8 feet, at every 16 feet lineal of the walls, forming recesses between, and leaving a central promenade of 21 feet wide, entirely unincumbered, except by the pillars which carry the second floor.

This arrangement allows ample space for purchasers, even when the central railway is filled with cars, and by means of the projecting stalls, furnishes a great development of stall surface, for the exposure of provisions on sale.

The building is of stone, two stories high, and the second floor is destined, in the course of time, to be also used for the sale of the lighter articles of marketing, which, brought to the market in cars, will then be elevated to the next story, by some convenient means.

Such is the outline of an enterprize which will probably form a prototype for others on a more extended scale, *since, the idea acted upon, seems to be a sound one, and must, eventually, have a very*

important effect upon the provisioning of those cities, which, by their railways, command the interior country.

Amer. Railroad Journal.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Cost of Transportation on Railroads. By CHARLES ELLET, JR., C.E.

(Continued from Vol. IV, page 367.)

The importance of ascertaining the expense of transportation on railroads, to a large portion of the population of this country, has led to many discussions, and many inquiries, with a view to its determination. No general method has, however, yet been produced, by which it can be ascertained with any tolerable degree of accuracy. The difficulty appears to have arisen, in a great measure, from the fact, that these expenses consist in a variety of elements, which increase and diminish in value by different laws, and at rates which depend on the combinations of these elements in each particular case. It has, also, to some extent, grown out of the fact, that during the progress of this system, every year has produced some new work of improvement, which has supplied new data to calculators—and, unfortunately, data which have preceded the effect of the two greatest causes of expenditure—the destruction consequent on use, and natural decay. Without referring to another difficulty—the extravagant estimates of the friends of particular projects, and, sometimes, the gross misrepresentations of the enemies of others—we see that the subject is much too complicated to be unraveled without close study, and mature reflection. To make a general solution, we have, obviously, to allow for differences of grade, differences of tonnage, differences between the amounts of travel, and have due regard to the length, and even the age of the improvement.

Now, to attempt to go through this whole subject, and produce and analyze the data on which are founded all my conclusions, would require much more labor, than I have a disposition, at this time, to appropriate to the question. What I now propose to do, is again to point out the LAW which governs railroad expenditures, and to fix, with greater accuracy, the values of the constant coefficients than was practicable when I first offered the formula which are here repeated.

It is my intention to submit, in the first place, the law which governs the expenditures on a *new road*, and attempt to offer a reasonable explanation, and a just estimate, of the difference between the expenses incident to a new road, and an old one. If my method be true, the reasons, and the values which I assign for this difference, must be obviously just. The general law must first satisfy the mind, and the rate of increase, in passing from a new to an old road, must likewise be rational and convincing. If, after this preparatory evidence, I bring forward a certain new road of great length, and show that the calculated cost corresponds well with the actual result, it will certainly be a strong confirmation of the general correctness of the method. But still, for a prudent man proposing to risk his fortune, this alone ought not to be sufficient. This particular example might be selected be-

cause it was accidentally found to suit the object; he would have a right, therefore, to call on me to produce a *short* road, and show that the results still correspond with my calculation. His intellect might not yet be fully satisfied; it would be fair for him to call for another example, in which the trade and travel were both unusually great, in order to be assured that the method is applicable to works of that character also; and, even after finding this result to be confirmatory of the method, extreme prudence would dictate an additional application to another road with very small trade.

All this appearing satisfactory, he could not well retain a doubt; but, when men stake their fortunes, and the comfort and indulgence of their families on the issue, they have a right—they are bound—to exercise great circumspection. Such a party might, therefore, well call for an application of the method to an *old road*—or to one that has arrived at maturity, at least,—in order to see whether his investment is likely to be permanently good.

If this doubt be also satisfied; if he finds that the application may be safely made to a road of this description; if, in addition, it is made to one of this sort with a great trade—next, to one with a small trade—then to one with great travel and no tonnage; afterward to a long one, and, finally, to a short one; to some roads with light, and to others with heavy grades—and, if he find that it gives consistent results in all these varied applications—as a reasonable, and as an intelligent man, he will be compelled to admit, that the method is in accordance with THE LAW, and that its results are the TRUTH.

It is such testimony that I propose to offer the reader, and I solicit his attention in order that he may judge fairly of my consistency—for consistency is a test of truth.

The following propositions are what I designate as Laws:—

I. The cost of motive power, with engines of the same class, is proportional to the distance which the engines run. The cost per mile is nearly the same on roads of all grades—the difference in expense on roads with different grades, consists not essentially in variations of the cost *per mile run*, but in variations of the number of miles which must be performed to do the same duty.

II. The repairs of the road, with equal trade, are proportional to its length; that is to say, *cæteris paribus*, it costs twice as much to keep up a road 200 miles long, as it does to maintain one in the same condition, of which the length is 100 miles; just as it costs twice as much to run engines 200,000 miles, as it would to run the same class of engines 100,000 miles.

III. The repairs of cars are proportional to the number of tons conveyed, and to the distance to which they are conveyed. It costs twice as much to repair cars which run two millions, as it does those which run one million of miles per annum. Again, it costs twice as much to repair cars which convey 20,000 tons a given distance, as it does those which convey 10,000 tons the same distance. The same principle applies equally to the conveyance of passengers; it applies also to accidents, incidentals, and contingencies—for these things increase with, and are proportional to, the increase of business.

These may appear like self-evident truths, and they are, in fact, so glaring that they scarcely appear to have been looked on at all. The custom now is to regard the expense of cars as proportional to the distance the *engine* runs. It is here made proportional to the distance the *cars* run. It is customary also to consider the repairs of the road as proportional to the distance traveled by the engine—whereas it is only proportional to the length of the road.

These are simple principles, and such as cannot well be doubted, or denied. It remains to state the values of the constants.

Repairs of Roads.

The repairs of a railroad, I have stated, must be divided into two classes—those which are dependent on, and those which are independent of, the amount of the tonnage. Of the first division, the wear of iron depends entirely on the use, and the wear of the wood, but partially on the use. The rotting of timber, the cleaning out of ditches, the repairs of culverts, embankments, &c., are independent of the trade. But these items are not independent of *time;* the expenses of repairs increase but little until the wood in the sills, ties and rails, begins to decay, and require removal, when they usually soon attain their maximum, and afterward diminish, until they reach a second minimum.

The following table exhibits the cost of repairs on six of the most successful roads in this country, which I have purposely selected from different sections. The table embraces three roads of each of the two great classes—three wooden superstructures with plate rails, and three iron roads with T or H patterns.

By casting the eye down the columns, the progressive increase of expenses will be easily recognized. It must be borne in mind, however, that these numbers do not include the renewal of the iron—an item always charged to "extraordinary repairs," or "permanent improvements"—as though iron rails were ever permanent, or their destruction extraordinary. Eventually, the cost of the new iron passes into capital stock, or funded debt.

TABLE showing the Increase of the Cost of Repairs of Railroads.

Year.	Permanent Roads—T Rail.			Wooden Roads—Flat Bars.		
	Boston & Lowell.	Boston & Provid'ce.	Boston & Worces'er	Utica & Schenec'y.	Petersburg Road.	S. Carolina Road.
1836					251	870*
1837	546	285	206	354	664	880
1838	611	411	281	330	542	1040
1839	731	209	405	450	539	982
1840	816	334	830	618	794	592
1841	1200	597	784	837	857	547
1842	1350	514	903	935		503
1843						375

I may add the following notes of the cost of motive power per mile traveled by the engines, which are extracted from documents that were not in my possession when I first stated the cost per mile for passenger engines at 25 cents, and of freight engines at 30 cents.

* Finished in 1833, when the expenses were very low.

TABLE showing the Cost of Locomotive Power for 1842.

Name of Road.	Miles run.	Expense.	Cost per mile.	Year	Remarks.
Boston and Providence.	35,031	$ 11,399	32½	1842	Freight engines.
Boston and Providence.	77,774	23,352	30	1842	Passenger engines.
Western Road.	397,295	84,165	21$\frac{1}{7}$	1842	Exclusive of wages.
Western Road.	397,295	115,000	30	1842	Wages included.
Utica and Schenectady.	155,828	33,454	21½	1841	Exclusive of new engines.
Utica and Schenectady.	155,828	52,268	33$\frac{6}{10}$	1841	Including new engines.
Reading Road.	83,717	17,443	20$\frac{8}{10}$	1841	With new engines.
Reading Road.	198,055	49,800	25$\frac{1}{4}$	1842	New, but heavier, engines.

This table entirely confirms the previous estimate (vol. iv, p. 307.) Another table in my possession (derived from reports of 1842) gives for the average value of repairs of locomotives, 7 cents per mile run; my impression is, however, that this item is worth not less than 8 cents, and that future observation will maintain it, for engines that are not fresh from the factory, at about that average.

We may now pass to the method and the rule which I propose for computing the aggregate annual expenses of a road. In the first numberof this investigation, I proposed a formula which was published in this journal, for determining the value of these expenses—stating, however, that there was no line in the country which had yet exhibited results as favorable as those expressed by that formula. The present paper is intended to show these expenses *as they are;* the same formula is used though the constants are modified to suit the actual condition of the system.

For new Roads.

The aggregate annual charges on *new roads** are made up of the following items, viz.:—

For every mile traveled by the engines, 24 cents; for every ton conveyed one mile, 9 mills; for every passenger conveyed one mile, 7 mills; and for every mile in length of the road, 300 dollars, a fact which is expressed by the formula,

$$\frac{24}{100}\,\mathrm{N}+\frac{9}{1000}\,\mathrm{T}+\frac{7}{1000}\,\mathrm{P}+300h.$$

Now, new engines consume as much, or nearly as much, fuel and oil as those which have been used; and they require the same number of enginemen and firemen. The only reduction in the cost of their maintenance, consists in the item of repairs. The bill for repairs for the first year or two, is only about one-half its mean value; and as the average cost of repairs is about 7 cents per mile run, the aggregate cost per mile run on a road which has passed its fourth year, should be 27½ cents, instead of 24 cents.

The *timber* in the superstructure is worth, on the average, from 1000 to 1500 dollars per mile, and lasts from 5 to 7 years. The decay of timber in roads of mature age, is, therefore, about $200 per mile—so that ordinary repairs on such roads will be about $500 per mile.

The wear of cars after the road has been a few years in operation, is equivalent to about 4½ mills per ton per mile; and on a new road

* I designate as *new*, roads less than five years old.

it is scarcely appreciable. The difference between the perceptible injury to the road and cars, on a new and old road, is about 5 mills per ton per mile. The rule then is,—

For old Roads.

For every mile traveled by the engines, (passenger engines 25 and freight engines 30 cents,) an average of 27½ cents; for every ton conveyed one mile, 14 mills; for every passenger conveyed one mile, 7 mills; and for every mile of road, $ 500.

If the principles and the values here offered be correct, they will stand the test of trial, and in order to make the test the strongest possible, I will add, in a subsequent paper, an estimate of the probable results on a road in active operation, and the subject of much speculation at the present time, the correctness of which estimate can be verified at the end of the year.

This rule, if applied to the business of a line in activity, will give only those expenses which are usually denominated "ordinary expenses." In order to arrive at the *true cost* of maintenance we have to add, of course, the extraordinary expenses, which we can likewise estimate with some, though not very great, accuracy, by data now supplied by the improvements of the country.

Application of the formula to Active Works.

I shall apply this method of computation, in the first place, to a railroad in Georgia, 147½ miles long, with easy grades and little business; next, to one in Massachusetts, 156 miles long, with grades of more than 80 feet to the mile, on which the engines travel nearly four hundred thousand miles per annum, and where the trade and travel are both great; I will then apply it to a short road in the State of New York, which carries no tonnage at all, but which derives its revenue entirely from passengers, and which has moderate grades, and a moderate business; next, I will make the application to a road in Maryland 70 miles long, with grades of 84 feet, and which derives two-thirds of its revenue from tonnage. Finally, I will apply it to a road in Pennsylvania 56 miles long, with favorable grades and moderate business—and again to the same road the next year, when extended 38 miles further, and having an increase of business.

The following table gives the length, grades and business of these roads; and, in the two last columns, are placed, side by side, the actual and calculated expenses.

TABLE exhibiting the actual and computed cost of maintaining New Roads, calculated from the formula,

$$\frac{24}{100}\,N + \frac{9}{1000}\,T + \frac{7}{1000}\,P + 300h.$$

Name of Road.	Length. miles.	G'de. in ft.	M. traveled by engines.	Thro' tonn'e.	Thro' travel.	Expenses.	Calculat'd expenses.	Year.
Georgia Road,	147½	37	152,873	10,000	12,000	$109,819	$106,605	1842
Western Road,	156	83	397,295	40,000	53,000	256,619	256,187	1842
Syracuse and Utica,	53		84,000		70,769	62,325	62,315	1842
Baltim'e & Susqueh'a.	70	84	128,349	23,000	16,500	75,224	74,379	1842
Reading Road,	56	19	83,717	24,000	31,453	62,635	61,318	1841
Reading Road,	94		198,055	65,600	33,720	138,900	152,911	1842

The roads named in this table are all those which have been completed less than four years, of which I have been able to procure the trade and travel, aggregate expenses, and distance run by the locomotive engines for the year 1842. In some of these I have been compelled to deduce the through tonnage from the receipts and prices —the reports giving only the aggregate tonnage ;—in general the through travel is given with precision.

The agreement between the actual and calculated results in this table, is most remarkable, and exhibits a degree of uniformity in the administration of the lines, which could not have been anticipated. Indeed it is most probably because the roads are so new that the agreement is so perfect. When they begin to feel the effects of time and use, they will give way unequally, and exhibit much wider deviations from the rule. This fact is exemplified in the following table, which exhibits the results of experience on ten important railroads, selected from different sections of the country. The roads in this table vary in length from 14 miles to 136 miles; in grades from 10 ft. per mile, to 83 ft. per mile; in freight from nothing to 94,000 tons; in travel from 7,000 to 180,000 passengers ; and in expenses from 30,000 to 225,000 dollars per annum.

TABLE exhibiting the actual and computed cost of maintaining roads which have been completed more than four years, calculated by the formula,

$$\frac{27.5}{100}N+\frac{14}{1000}T+\frac{7}{1000}P+500h.$$

Name of Roads.	Year.	L'gth in miles.	G'de. in feet.	Miles run.	Thr'gh tonna'e	Thr'gh travel.	Actual expenses.	Calculat'd expenses.
Boston and Providence,	1842	42	38	120,000	21,200	117,129	$101,596	$100,897
Baltim'e and Washing'n,	1841-2	30½		91,428	27,369	114,260	73,684	76,166
Petersburg Road,	1842	61	30	131,160	22,000	16,000	96,398	92,489
Nashua and Lowell,	1841	14	10	44,040	28,663	85,737	30,708	33,131
Baltimore and Ohio,	1842	82	82½	299,617	44,477	34,380	220,135	192,925
Portsmouth & Roanoke,	1842	79		96,000	5,975	7,662	73,345	76,703
Boston and Lowell,	1842	26	10	143,607	93,927	179,819	131,012	119,409
Philadelp'a & Columb a,	1842	82	45	261,844			116,000	112,979
S. Carolina Road,	1842	136	35	260,324	27,000	24,000	225,743	213,945
Boston and Worcester,	1842	44½	42	241,319	61,911	165,720	168,509	176,815
Utica and Schenectady,	1841-2	78		152,764		114,527	154,436	143,542

[NOTE.—The miles run on the *Petersburg Road* are assumed to be the same as in 1841; the tonnage is estimated from the tonnage of 1841, with an allowance for the increased receipts. The results on the *Baltimore and Ohio Road* for 1841 are preferred, because those of 1842 are complicated by the extension of the line to Cumberland. The report of the *Philadelphia and Columbia Road* contains only the expenses of motive power and repairs; the freight and passengers are conveyed by other parties ; we have, therefore, in the formula to make $P=0$ and $T=0$, for this case. The tonnage and travel on the *South Carolina Road* are deduced from the printed reports. The actual charges on some of the lines will be seen to differ from other published statements; this will be found to arise from the fact that

these statements contain charges for interest, ferries, cars, and motive power on branch roads, which are rejected in this comparison.]

Here is presented a list of eleven roads, situated in different sections of the country, and offering every variety of length, grade and business that could be desired, in order to put the formula to the severest test. The greatest difference which is exhibited in the whole list between the actual annual cost of maintenance, and the estimated cost, *is* 12 *per cent.;* certainly no closer agreement could be expected, since the actual expenditures fluctuate to that extent—and, perhaps, through wider limits—from year to year; the removals of decayed timber, and various contingencies, being found much more extensive some years than others. In looking over the list I am able to account, in almost every instance, for these departures from the formula, by my personal knowledge of the situation of the line. It will probably be seen on some future occasion, that those roads which now exhibit expenses above the formula, will fall below it for other years—a remark which is applicable to the Boston and Lowell, Baltimore and Ohio, and South Carolina Roads.

It is no part of my object to flatter the expectations of railroad companies, but to exhibit to them and the public the truth; to those companies whose works are now new, and who *seem* to be making money, I would suggest the timely formation of a contingent fund, to prepare them for a contingency which will as surely reach them as the next new year. It is bad policy to divide the *annual expenses* as if they were real profits; the money that is earned at the expense of the rails, cars, and machinery, should be hoarded to replace those things, and not distributed, as if they were to last forever. It can be shown that every company should annually store away, in times of prosperity, while their work is new, at least 6 cents for every mile travelled by their engines, 1 cent for every ton conveyed one mile, and 200 dollars for every mile of road, to replace decayed materials, and injured iron and machinery. If their profits will not permit that reservation, then the prudent man will avoid their stock; and the company should cut down their expenses to the limit assigned by the trade. Where these expenses do not consist of interest on debt, this retrenchment is almost always possible.

In the first of these tables the Reading Railroad appears to escape the application of the rule; the calculated expenses exceeding the actual charges, as stated by the company, some $14,000, or about 10 per cent. There has probably been a division made between the current and contingent expenses on this line; indeed, on inspecting the published exhibit, I find that the whole sum set down for *timber* used in repairing 94 miles of road, including rails, sills, &c, is just $2,431. Now, I know personally, that twice that sum would not pay for the timber required for repairing the bridges alone; the bridge account last year must have amounted to more than $12,000, and seems not to be included in the published statement. This sum being added to the published total, brings the year's expenses up to $151,000, or within 1¼ per ct. of the formula. Perhaps the company regard the loss of a bridge as so extraordinary an occurrence, that it can never take place again; but

their report already points to another which is found to be "less permanent than the rest;" and time will show that no part of railway superstructures will long remain permanent under the action of heavy engines and their trains. Besides there will be freshets, and tornadoes, and fires; and on a road which has a great many bridges constructed of perishable materials, and which is travelled by 25 or 30 locomotives every day, or about 10,000 trains a year—with engines using pine wood for fuel—many accidents must be expected. One bridge per annum is a small allowance for the average loss; and if the bridges happen to be fortunate, there will be rotten sills, or crushed iron, enough to compensate for the difference.

We perceive then that the formula applies also to this road; and I will now insert a table exhibiting its application to all the roads of which I have been able to obtain the amount of trade, and annex a column showing the per centage of error for each; not having the number of miles run by passenger and freight engines separately in every instance, I make use of the mean value 27½ cents per mile run.

TABLE.

Name of Road.	Year.	L'th.	G'de.	Miles run.	Through tonnage.	Through travel.	Actual expenses.	Calculated expenses.	Err'r pr.ct.
Georgia Road,	1842	147½	37	152,873	10,000	12,000	$ 109,819	$ 106,605	−2¾
Western Road,	1842	156	83	397,295	40,000	53,000	256,619	256,187	0
Syracuse and Utica,	1842	53		84,000		70,769	62,325	62,315	0
Baltimore and Susque'a.,	1842	70	84	128,349	23,000	16,500	75,224	74,379	−1
Reading Road,	1841	56	19	83,717	24,000	31,453	62,635	61,318	−2
Reading Road,	1842	94	35	198,055	65,000	33,720	151,000	152,911	+1¼
Boston and Providence,	1842	42	38	120,000	21,200	117,129	101,596	100,902	−¾
Baltim. and Washington,	1841-2	30½		91,428	27,369	114,260	73,684	76,193	+3¼
Petersburg Road,	1842	61	30	131,160	22,000	16,000	96,398	92,310	−4
Nashua and Lowell,	1842	14	10	44,040	28,663	85,737	30,708	33,131	+8
Baltimore and Ohio,	1841	82	82½	299,617	44,477	34,380	220,135	192,925	−12
Portsm'th and Roanoke,	1842	79		96,000	5,975	7,662	73,345	76,703	+5
Boston and Lowell,	1842	26	10	143,607	93,927	179,819	131,012	119,409	−9
South Carolina Road,	1842	136	35	260,324	27,000	24,000	225,743	213,945	−5
Boston and Worcester,	1842	44½	42	241,319	61,911	165,720	168,509	176,831	+6
Utica and Schenectady,	1841-2	78		152,746		114,527	154,436	142,542	−8
Philada. and Columbia,	1842	82	45	261,744			116,000	112,979	−2½
Aggregate,		1251		2,886,292	Tons 1 mile. 33,360,560	Pas. 1 mile. 57,726,906	$ 2,109,188	$ 2,068,165	

One word more in reference to this table. I offer here a list of 17 railroads, presenting almost every conceivable variety of length, grade, and character. It is not a *selected* table, but contains the results of one year's operations on *every* road, without exception, concerning which I have been able to obtain the necessary data—materials which have only been procured by dint of great exertion. It will be seen that the management upon these various lines is very nearly uniform, and that they are *all* obedient to the *law*. The greatest departure from the formula is 12 per cent.

Now, this list embraces roads which are situated in every one of the sea-board States from Maine to Georgia; the aggregate length of line exhibited is 1251 miles; the engines traverse annually a space of 2,886,300 miles, and they carry no less than 33,360,560 tons, and 57,726,906 passengers one mile. The aggregate ordinary expense of maintaining this length of line, and accommodating this amount of tonnage, is actually $2,109,188 annually, and the calculated expense $2,068,165. The difference between the calculation and the fact is $41,023, or less than two per cent.

I conceive, therefore, that I have authority sufficient for announcing this formula as expressing the law of railroad expenses—a law to which all the roads in the country are obedient. If stronger evidence of its correctness could be offered, I know not in what it would consist. It is in vain to urge here that a certain road has peculiarly steep, or peculiarly light, grades, which should exempt it from the application of the rule. The formula which I announce, accounts for these differences. When the grades are easy, the engines make fewer miles, and the rule looks only to the miles.

There is yet another point of great importance connected with this subject, which ought not to be overlooked, viz., the "extraordinary expenses." It is the custom among too many of the parties interested in the railroads of this country, to look upon the suggestion that iron may be worn out, as a thing so chimerical and visionary, as to be entirely unworthy of their sober thoughts. In the course of a few years they are surprised by the fact—the certainty—that money must be raised, and that their iron *must be* renewed. Instead of being warned by experience, and commencing immediately the work of retrenchment, and the provision of a surplus fund to meet the recurrence of the contingency, they look upon it as extraordinary in the extreme—a sheer accident, which cannot occur again, or which can be warded off by a heavier iron. Experience and common sense teach that heavier iron will be attended with heavier expense; but they have *not yet* taught that the wear will be less. A heavier rail will longer resist a given trade; but will each dollar put into the heavy rail go farther? This, however, is a subject which must be reserved for a future number of the Journal.

To be Continued.

Mechanics, Physics, and Chemistry.

A notice of the occurrence of a Metallic Alloy in an unusual state of aggregation and molecular arrangement. By Robert Mallet, Esq., M.R.I.A.

Amongst the several classes of substances which chemistry at present considers as simple, the metals stand pre-eminently marked by their almost invariable possession of a nearly fixed and striking group of sensible qualities, which together constitute the well known "metallic character." Some of these, such as lustre and fusibility, are common to every metallic body; but by the occasional variation of nearly every other sensible quality of the metals, the law of continuity remains unbroken, which unites them in different directions with the other classes of material bodies. Thus opacity, which is probably mechanically destroyed in gold leaf, is lost in selenium; and so, in this most prevalent of their properties, the metals, through tellurium, selenium, and sulphur, become translucent, and mingle with the non-metallic elements. So also their solidity, at common temperature, is lost in mercury; their great density, in sodium and potassium; their malleability, in bismuth, antimony, and arsenic; while in tellurium, the power to conduct electricity is nearly wanting; and, lastly, hydrogen, to all intents a metal in its chemical relations, yet possesses not a single physical quality in common with these, but exists as an invisible and scarcely ponderable gas.

But although *different* metals thus vary in sensible qualities, those which collectively belong to the *same* individual metal are as remarkable for their permanence.

Unless selenium be admitted to be a metal, no approach to dimorphism has hitherto been recognized in any body of the class; the only case recorded, that by Dufresnoy, of the occurrence of cast-iron in cubes and rhomboids, not having been given by him with certainty, nor since verified by other observers. Hence, any instance of such a character, or tendency towards it, is worthy of attentive consideration; and it was with this view that the author brought before the Academy the following notice of the occurrence of an alloy of copper in two states, having totally different sensible and physical qualities, while identical in chemical constitution. The alloy in question, in its original, or normal, condition, was, in fact, a species of brass; and the particular specimen presented to the Academy, was a portion of one of the brass bearings, or beds, in which the principal shaft of a large steam engine revolved.

The bearing, or bed, of a shaft (as is generally known,) consists of a hollow cylinder, generally of brass, divided in two by a plane passing through the axis; its inner surface is finely polished, and sustains the shaft, during its revolution, which is also polished; the cavity of the brass being completely filled by the shaft, which, in the present instance, was of cast-iron, and about nine inches in diameter.

It frequently happens, notwithstanding the polish of both metallic surfaces, and the application of oil, that the friction due to their rapid passage over each other, while exposed to undue, or irregular, pressure, produces a considerable rise of temperature, and the brass becomes abraded. Its particles have no coherence, and much resemble the "bronze powder" used by painters.

In an instance, however, which some time since came under the author's notice, a different result took place. The minute particles of abraded brass, were, by the motion of the shaft, during a few hours, impacted into a cavity, at the junction of the two semi-cylinders of the bearing, where they became again a coherent mass, and when removed, presented all the external appearance of an ingot, or piece, of brass which had been poured in a state of fusion into the cavity. On more minute examination, however, the mass was found to differ much in its properties from the original brass, out of which it was formed.

The mass, or ingot, of brass, thus formed by the union of particles at a temperature which had never reached that of boiling water, and a fragment of which was presented, possessed on that side which had been in contact with the shaft, a bright polished metallic surface, like that of the original metal from which it had been formed: its other surfaces bore the impress of the cavity in which it was found. It was hard, coherent, and could be filed, or polished, like ordinary brass. It was, however, perfectly *brittle;* and when broken, the fracture, in place of possessing a sub-crystalline structure and metallic lustre, like that of the normal brass, or alloy, was nearly *black*, and of a fine grained *earthy* character, and *without any* trace of *metallic lustre*, or appearance.

Examined with a lens, some very minute pores, or cavities, are found throughout its substance, which is uniformly of a very dark brown, or nearly black, color, and devoid of all metallic character, except when cut, or filed—that is, in mineralogical language, its color is earthy black, and its streak metallic.

The author remarked that the observed cases of aggregation in solid particles, without the intervention either of a solvent, or of fusion, are extremely rare, and, as bearing upon the little understood subject of cohesive attraction, are of much interest.

The property of welding, which is possessed by all bodies, whether metallic, or not, which pass through an intermediate stage of softness, or pastyness, previous to fusion, and is not found in any substance which readily crystallizes, and hence passes *per saltum* from the solid to the liquid state by heat, forms a "frontier instance" of cohesive forces, being enabled to act in the aggregation of bodies, by only an approach to liquidity, or by a very small degree of intermobility.

Aggregation may also take place between portions of a body merely *softened* by a solvent, which is afterwards withdrawn, as in the familiar instance of India rubber, softened by naphtha for the manufacture of waterproof cloths; where the former, after being moulded, or united, in any way required, is left in its pristine condition by the evaporation of the naphtha from amongst its particles. But the cases

of aggregation of solids, without such elevation of temperature, or the presence of solvents, are so rare, that but two or three have as yet been observed. Of these the most remarkable is that recorded by Pouillet, of the gradual, but complete, adhesion of surfaces of clean plate-glass, when left to repose on each other for a considerable time. It has also been stated, that clean plates of lead, or of tin, if pressed together by a considerable force when cold, require a proportionally great force to separate them. The case presented to the Academy, therefore, is another added to these rare instances of molecular aggregation in solids, independent of solution of fusion: the author, therefore, thought it worth while to examine, with a little care, the properties, both of the original brass, and of the mass thus curiously formed from it, or, as he thenceforth called them, of the *normal*, and the *anomalous* alloy.

The normal alloy is of a bright gold color, and sub-crystalline in structure, and of great toughness; its cohesive force is equal to 21.8 tons per square inch, which is above the average strength of any of the alloys of copper and zinc, or copper and tin, as found by my experiments on the cohesive power of these alloys, published in the proceedings of the Academy, and elsewhere. The cohesive force of the anomalous alloy is only 1.43 ton per square inch, or only about one-fifteenth that of the former.

The specific gravity of the normal alloy is = 8.600; that of the anomalous only = 7.581.

On submitting both alloys to analysis, their constitution proved identical; it is as follows:—

Copper, - - -	83.523
Tin, - - -	8.833
Zinc, - - -	7.510
Lead, - - -	0.024
Loss, - - -	0.110
	100.000

Uniting the small amount of lead with the tin, and dividing by the atomic weights, the nearest approach to atomic constitution is,

Copper,	=	26.3 atoms.
Zinc,	=	2.3 "
Tin	=	1.5 "

These alloys have therefore not a strictly definite constitution, but one more nearly so than is usually found in commerce.

Both alloys are equally good conductors of electricity. The author examined their relative powers of conducting heat by the method which Despretz has employed with so much accuracy, and found that of the normal to that of the anomalous alloy as 36 : 35, numbers which are so nearly equal as to render it likely the difference is only error of experiment. He also endeavored to determine their relative specific heats, using the method of mixture, which was the only one which the small size of the metals permitted, and eliminating the errors in-

cident to this mode, by first plunging the alloy hot into cold water, and then cold into hot water. In this way, if,

W and t = the weight and temperature of the water,
M and t' = the weight and temperature of the metallic alloy,
m .... = the mean temperature of both,
S .... = the specific heat of the alloy,

there are two values, one where the metal is the hotter,

$$S = \frac{W(m-t)}{M(t'-m)};$$

and another where the water is the hotter body,

$$S = \frac{W(t-m)}{M(m-t')};$$

the mean of which is the specific heat of the alloy pretty exactly. The result gave the specific heat of the normal alloy = .0879, water as unity, and that of the anomalous alloy = .0848; both of which are below the specific heat assigned by Dalton to brass.

The normal alloy is malleable, flexible, ductile, and laminable. In the anomalous alloy there is an absolute negation of all these properties.

The normal alloy readily amalgamates with mercury at common temperatures; the anomalous alloy will not amalgamate with mercury even at 400° Fahrenheit.

When the anomalous alloy is heated to incipient redness in a glass tube, a minute trace of water, and of a burned organic substance probably adherent oil, are discoverable; it suffers no change, however, but a slight increase of density. The normal alloy suffers no change when so treated. The normal alloy, treated on charcoal with the blowpipe, fuses at once into a bead. On treating the anomalous alloy so, the fragment swells rapidly to more than twice its original bulk, on becoming bright red-hot; it then glows, or becomes spontaneously incandescent, in the way that hydrated oxide of chrome, and some others do, and instantly contracts to less than its original bulk, and becomes a fluid bead, which, on cooling, differs in no respect from the original alloy.

The anomalous alloy, when pulverized in an agate mortor, forms a *black powder*, devoid of all appearance of a metal; its filings also are quite *black*; while those of the normal alloy, produced by the same file, possess the usual metallic lustre. These facts, in connexion with the black color and fine earthy appearance of the fracture, bring to mind the case recorded by Sir David Brewster, of a piece of smoky quartz, the fracture of which was absolutely black, and yet was quite transparent to transmitted light, and whose blackness, he found, arose from the surfaces of fracture, consisting of a fine down of short and slender filaments of transparent and colorless quartz, the diameter of which was so small (not exceeding the one-third of the millionth part of an inch,) that they were incapable of reflecting a single ray of the strongest light. In describing this, Sir David Brewster predicted that "fractures of quartz, and other minerals, would yet be found

which should exhibit a fine down of different colors, depending on their size."

It seems, therefore, extremely probable that the cause of the near approach to blackness in the fracture and filing of this alloy, arises from the excessive minuteness of its particles, and thus fulfils the foregoing prediction; the brownish tinge being produced by the reflexion of a little red light.*

The polish and power of reflecting light of the anomalous alloy, are not quite so great as those of the normal, but are still remarkable; and, as it seemed a matter of some interest to determine whether both reflected the same quantity, or intensity, of light at equal angles, the author endeavored to ascertain this point as respects heat, by means of Melloni's pile for the galvanometrical determination of temperature, assuming, as suggested to him by Professor MacCullagh, that what would be true of heat in this respect, would also be so of light; but from the small size of the reflecting surfaces he had at his command, he found it impossible to arrive at any trustworthy result. He is, however, inclined to believe, that both metals reflect most at a perpendicular incidence.

From the foregoing detail of the properties, in several respects so different, of this substance in its normal and anomalous states, the author thinks he is warranted in pronouncing it the first observed instance of an approach to dimorphism in a metallic alloy; and one, the mode of production and characteristics of which present several points of interest.

The conditions under which the alloy was aggregated, involved extremely minute division of the metal, great pressure in forcing the divided particles into contact, and nearly the exclusion of air. Considerable electrical disturbance may have also co-operated; such, together with induced magnetism, being the constant accompaniments of motion in heavy machinery. By re-establishing these conditions, under suitable arrangements, the author hopes to repeat the results thus accidentally first obtained, and so produce possibly dimorphous states of other metals, or their *definite* combinations.

There is but one body which occurred to the author presenting an analogy to this anomalous alloy, namely, indigo; whose fracture, it is well known, is fine earthy, and of the usual blue color, but becomes coppery, or assumes the metallic lustre on being rubbed, or burnished.

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On Palladium—its extraction, alloys, &c. By WILLIAM JOHN COCK, ESQ.†

This metal was discovered by Dr. Wollaston, in the year 1803,‡ as

* Since this paper was read, Professor Lloyd suggested to the author, the analogy between the appearance of the powder and filings of the anomalous alloy and platina mohr, and those powders obtained by reduction of other metals by hydrogen. None of these, however, are coherent, which constitutes the peculiarity in the present case.

† Communicated by the Chemical Society; having been read January 3, 1843.

‡ Dr. Wollaston's original paper on Palladium, reprinted from the Philosophical Transactions, will be found in Phil. Mag. S. 1, vol. xx, p. 163; see also vol. xv, p. 287.—ED.

one of the alloys of native platinum, which, for some time after this discovery, appears to have been considered the only source of palladium; and as the quantity of the latter metal so alloying the native platinum is very small, it was then considered as a very rare metal: of late years, however, the importation into this country from Brazil of gold dust, alloyed with palladium, has occasioned a much more extensive supply of this metal, as it exists in some specimens of gold dust, to the extent of 5 or 6 per cent., and in one instance (that of the gold from the Candonga mine) it constitutes the only alloy of the gold.

The operation of refining is conducted in the following manner:—The gold dust is fused in charges of about 7 lbs. troy, with its own weight of silver, and a certain quantity of nitrate of potash; the effect of this fusion is to remove all earthy matter, and the greater part of the base metals contained in the gold dust, and in the silver melted with it. The fused mixture is cast into ingot moulds, and when cooled, the flux, or scoria, (containing the oxides of the base metals, and the earthy matter, combined with the potash of the nitre) is detached. Two of the bars thus obtained are then remelted in a plumbago crucible, with such an addition of silver as will afford an alloy containing one-fourth its weight of pure gold, and which being first well stirred to insure a complete mixture, is poured through a perforated iron ladle into cold water, and thus very finely granulated; it is then ready for the process of parting. For this purpose about 25 lbs. of the granulated alloy is placed in a porcelain jar, upon a heated sand-bath, and subjected to the action of about 25 lbs. of pure nitric acid, diluted with its own bulk of water; after the action of this quantity of acid, the parting of the gold is very nearly effected; but to remove the last portions of silver, &c., about 9 or 10 lbs. of strong nitric acid is boiled upon the gold for two hours. It is then completely refined, and after being washed with hot water, is dried and melted into bars containing 15 lbs. each.

The nitrous acid gas, and the vapor of nitric acid arising during the above process, are conducted by glass pipes (connected with the covers of the jars,) into a long stone ware pipe, one end of which slopes downwards into a receiver for the condensed acid, the other end being inserted into the flue for the purpose of carrying off the uncondensed gas.

The nitrate of silver and palladium obtained as above, is carefully decanted into large pans, containing a sufficient quantity of solution of common salt to effect the precipitation (as a chloride) of the whole of the silver, the palladium and copper remaining in solution in the mother liquor, which is drawn off, and when clear is run off, together with the subsequent washings from the chloride of silver, into wooden vessels, and the metallic contents are then separated in the form of a black powder, by precipitation with sheet zinc, assisted by sulphuric acid.

The chloride of silver, when washed clean, is reduced by the addition of granulated zinc, washed on the filter with boiling water,

dried and melted in plumbago crucibles, without the addition of any flux.

From the black powder obtained as above, the palladium is extracted by resolution in nitric acid and super-saturation with ammonia, by which the oxides of palladium and copper are first precipitated, and then redissolved, while those of iron, lead, &c., remain insoluble. To the clear ammoniacal solution, muriatic acid is then added in excess, which occasions a copious precipitation of the yellow ammonio-chloride of palladium, from which, after sufficiently washing it with cold water and ignition, pure metallic palladium is obtained. The mother liquor and washings contain all the copper and some palladium, which are recovered by precipitation with iron.

Pure palladium is of a greyish-white color, rather darker than that of platinum; it is both malleable and ductile, though inferior in those qualities to pure platinum; its specific gravity is 11.3, which may be raised by hammering, or rolling, to 11.8. When perfectly pure it cannot be fused even in small quantities in ordinary blast furnaces, but may be brought into such a state of agglutination as to bear laminating, or drawing, into wire.

It may be completely fused by means of oxygen gas, and being kept some time fused, it is said to burn with the production of brilliant sparks; it is not tarnished by exposure to sulphuretted hydrogen, nor oxidated by the air at the ordinary temperature, or at a bright red heat; but it has the singular property of becoming oxidated by exposure to air at a dull red heat, the surface becoming colored in the same manner as iron or steel; and by continuing the process cautiously for some time, the metal becomes coated with a brittle crust of oxide of a brown color; this oxide is, however, reduced by a temperature very little higher than that necessary for its formation, and the surface of the metal regains its original color upon being heated to a bright red, and cooled out of contact with the air.

It is with difficulty soluble in nitric acid when pure and fused, or in a state of aggregation, but is readily so when alloyed to some extent with silver, or copper, and still more so when in the form of the black powder above referred to, in which state it is also soluble with the aid of heat in sulphuric and muriatic acids; but its proper solvent is nitro-muriatic acid, which, if it be not very much alloyed with silver, dissolves it readily.

It is, of all the metals, that which has the greatest affinity for cyanogen; and by means of cyanide of mercury, it may be separated from all its solutions.

It may be alloyed so as to be malleable with gold, silver, and copper; several of its alloys, with the two latter metals, being of great use in the arts from their hardness and elasticity, and non-liability to rust, or tarnish. When added to gold or copper, it whitens both those metals in a very great degree, about 20 per cent., being sufficient, in either case, to destroy the color of those metals.

The uses to which the alloys of palladium have been applied, are for the points of pencil-cases, for lancets for vaccination, for the graduated scales of instruments, as a substitute for gold in dental surgery,

or for any purpose where strength and elasticity, or the property of not tarnishing, is required. Ibid.

Account of a series of experiments on the comparative strength of solid and hollow Axles. By JOHN OLIVER YORK, Assoc. Inst. C. E.

The author first describes the causes of fracture in railway axles, which he attributes to the sudden strains and injury produced by concussion and vibration. Those resulting from concussion are chiefly ascribed to a defective state of the permanent way, any sudden obstacle opposing itself to the progress of the train, and the severe shocks arising from the wheels coming in contact with the blocks and sleepers when thrown off the line. The force of vibration, and its certain effect to produce fracture in a body so rigid as a railway axle, is then fully explained; the evil arises from the impossibility of diverting from the axle the continued series of slight blows, or vibrations, to which it is subject, or of causing a free circulation of them through its entire length, since the naves of the wheels being fixed tightly on to the axles, form a point on either side for the vibrations to cease, and the particles of iron composing the axle at this point become dislocated by the continued and unequal strain, and ultimately break; the same action is described as taking place in the journal of the axle, and hence the fact that an axle seldom breaks excepting at the journal, or at the back of the nave of the wheel. The twisting strain to which railway axles are subject, is next considered, and a calculation entered into, to prove that upon a circle of only a few feet in diameter, and assuming a first-class carriage on four wheels to weigh 6 tons, the strain resulting from this cause is so slight, as to be unworthy of consideration in the inquiry. The paper next proceeds to point out, how and why the hollow axle is better able to resist the strains before referred to, than the solid ones now in use.

First, by the process of manufacture, by which the crystalization of the iron is avoided, and it is left in a better state for sustaining sudden strains and continued action. Secondly, by the position of the metal composing the axle, since the comparative strengths of axles are as the cubes of their diameters, and their comparative weights only as their squares,—consequently, with less weight, there must be increased strength: and thirdly, that the vibration has a free circulation through the length of the axle, no part being subject to an unequal shock from the vibration, and the axle would, therefore, receive much less injury from this cause. In conclusion, it is submitted that a railway axle should possess the greatest possible degree of rigidity between the wheels, to prevent it from bending, or breaking from concussion, combined with the greatest amount of elasticity and freedom in the particles of iron within the axle itself, to prevent the injurious effects of vibration.

The details of a numerous set of experiments are then given, to prove the superiority of the hollow axle in all these respects; the average of the whole of which is thus stated.

As regards rigidity to sustain a dead weight:—

The axles being supported at the ends, and the weights applied in the middle.

Hollow Axles.						Solid Axle.			
Weight.				Deflect'n.	Perman't Set.	Weight.		Deflect'n.	Perman't Set.
Tons.	Cwt.	Qrs.	Lbs.	Inch.	Inch.	Tons.	Cwt.	Inch.	Inch.
7	14	. .	6	$\frac{1}{16}$	. .	7	14	$\frac{5}{16}$	$\frac{1}{16}$
9	2	. .	. .	$\frac{3}{16}$	. .	8	1	$\frac{3}{8}$	$\frac{5}{32}$
9	16	. .	. .	$\frac{3}{8}$	$\frac{1}{8}$				

As regards its capability to resist a falling weight:—

5 cwt. 3 qrs. 6 lbs. falling from a height of 16 feet on to the centre of the axle.

Hollow Axle.		Solid Axle.	
1st blow, deflection,	$1\frac{1}{2}$	1st blow, deflection,	$1\frac{3}{4}$
2nd " "	$2\frac{1}{4}$	2nd " "	$3\frac{1}{4}$
3rd " "	$3\frac{1}{4}$	3rd " "	$4\frac{1}{4}$

As regards the elasticity and fibrous quality of the journals:—

Hollow Axle.		Solid Axle.	
Number of blows to destroy journal (average),	28	Number of blows to destroy journal (average),	10

Proportions of axles:—

	Hollow Axles.	Solid Axles.
Diameter,	4 inches.	$3\frac{1}{2}$ inches.
Weight,	1 cwt. 2 qrs. 20 lbs.	1 cwt. 3 qrs. 24 lbs.

The paper is illustrated by specimens of the broken axles, both hollow and solid, and by diagrams of the mode of manufacturing the two kinds of axles.

Mr. Geach presented a series of specimens of ends broken off solid axles, made by the Patent Shaft and Axle Company, Wednesbury; they had borne severally 886, 148, 293, and 278 blows of a sledge-hammer, weighing 38 lbs., before they separated from the body:—above twenty more ends had been broken off, the weakest requiring 138 blows. The diameter of these journals was $2\frac{1}{2}$ inches.

An axle was exhibited which had been bent nearly double under an hydraulic press, with a pressure of 64 tons: the journals ($2\frac{1}{2}$ inches diameter) were also bent in opposite directions, by repeated blows of a sledge-hammer, without any signs of fracture being perceptible.

The firm, which Mr. Geach represented, had made upwards of twenty-five thousand axles, and had tried a very large number by breaking them; they almost uniformly found them of good quality,

which might be attributed to the mode of manufacture. Around a centre bar of iron were placed eight bars, rolled to a proper form, to complete a circle, the joints radiating from the centre; they were then welded together by rolling, and finished under the hammer; the fibre of the iron, it was contended, was thus worked, and remained in its most favorable position.

He was not opposed to the principle of hollow axles, but he wished to prevent any unnecessary prejudice against solid ones, by inferences from any one set of experiments; he would, therefore, suggest that another series of experiments should be made between the relative strength of the two kinds of axles, for which he would contribute the necessary number of solid ones.

Mr. York described the manner in which the solid axles had been selected for the purpose of experiment. Having obtained General Pasley's consent to be present on the occasion, he ordered axles from the Patent Axle Company, and another eminent maker, and selected also several other axles supplied by the Patent Axle Company to the London and Birmingham Railway; these axles were new, never having been under any carriage; he contended that the result of the experiments afforded a fair specimen of the axles generally in use, and were such as the public were in the habit of riding upon. The axles which had since been made by the Axle Company, and were then exhibited to the meeting, showed a quality of iron that could not be surpassed: if this was the usual quality made use of by that company, it still more forcibly proved his position as to the uncertainty of manufacturing solid axles, for while one specimen took a great number of blows to break it, the majority of them were fractured by a slight force; it was this uncertainty which he proposed to avoid, and he contended that it was inseparable from the method of making axles described by Mr. Geach; for, in passing the faggot through the rolls to weld the bars together, it frequently happened that they were only united to a depth of one-half, or three-quarters, of an inch; hence, it was, to a certain extent, hollow, and partially avoided the injurious effect of hammering; if, on the contrary, they were perfectly welded, the iron became crystalized, as in any other solid axle: this fact was proved by the specimens before the meeting, those that were solid having been broken by a very little force, and the unsound ones requiring a great number of blows to produce fracture.

In the experiments, the hollow axles had broken under a different number of blows, but this was owing to their having been made of larger diameter in the journals, than the solid ones, (but with only an equal quantity of metal in them,) and afterwards turned down to the same diameter, which left them of unequal thickness, and too thin for a fair test; still, however, with less metal than in the solid ones, they were stronger; this might be accounted for by the mode of manufacture, as by retaining the axle hollow, the crystalization of the iron was avoided.

The present mode of making the hollow axles, he described to be by taking two trough-shaped semi-circular pieces of iron, bringing their edges together, and welding them under a hammer between

swages. He, however, dissented from the process of hammering, and intended to finish his hollow axles by compression only. This, he contended, would avoid the injury done to the iron by the present mode of manufacture, and that with the same quantity of iron, the strength of axles being as the cubes of their diameters, and their weights only as the squares, a hollow axle must possess considerable advantage over a solid one.

Hollow axles had long been considered desirable, but the expense of making them had hitherto prevented their use; he had reduced their cost, by his process, to the same rate as the solid ones, and felt confident that in bringing them under the consideration of the profession, through the Institution, they would be faily treated, and ultimately adopted.

General Pasley confirmed the correctness of the results recorded by Mr. York, and the satisfactory nature of the experiments which had impressed him with a favorable opinion towards hollow axles. It was of importance to avoid deflection, as it was almost as fatal as fracture in causing accidents. After the late accident on the North Midland Railway, he observed a solid axle bent into the form of the letter C, and the upper portions of the periphery of the wheels nearly touching each other. The hollow axles would certainly resist deflection better than solid ones of corresponding weight.

In answer to a question, Mr. York said that the iron was chiefly injured by the amount of hammering which it received in forging.

Mr. Taylor remarked, that the question of the amount of injury received by iron in working, was discussed at the meeting of the British Association in 1842, and the effects of vibration and electricity had also been treated of by foreign engineers. It appeared to be generally admitted, that the great source of mischief was the cold swageing, which the iron received, in order to give the work a good appearance. In order to test this, Mr. Nasmyth subjected two pieces of cable bolt iron to 160 blows between swages, and afterwards annealed one of the pieces for a few hours. The unannealed piece broke with five or six blows of a hammer, showing a crystalized fracture; while the annealed piece was bent double under a great number of blows, and exhibited a fine fibrous texture. The fact of the fibre being restored by annealing was well understood and practiced by smiths, particularly in chain-making.

Mr. York could not entirely subscribe to the great benefit of annealing, as he had found that after annealing one end of a hollow axle for forty-eight hours, it was broken off by 32 blows, while the other (unannealed) end of the same axle resisted as far as 78 blows.

In answer to a question from Alderman Thompson, Mr. York said, that he had found as much mischief arise from over-heating iron, as from over-hammering it; but the difference of the appearance of the fracture, indicated immediately when iron had been burned.

Mr. Taylor said that in Mr. Nasmyth's experiments, the over-heated iron was almost as fragile as glass.

Mr. Gravatt believed that vibration, whether caused by the smith in working the iron, or by the use to which the bar was appropriated,

was the reason of its fracture, and it was certain that a constant change was going on in all manufactured iron. At the Thames Tunnel, the "fleeting bars," used as levers for turning the large screws for forcing forward the shield, never lasted longer than three or four weeks, although they were very strong, and were made from the best materials by careful smiths. They were only used occasionally, and then without any concussion, having only the power of eight men exerted upon them: yet they broke constantly, and the fracture exhibited a bright crystalized appearance. It was found at last, that in order to give them duration, they should be left rough, and not hammered much in working.

Mr. Newton observed, that full ten years since, Dr. Church had used hollow axles for his experimental steam coach on common roads, being convinced of their superiority.

Mr. Fox was an advocate for the hollow axles, but he did not consider the present experiments quite conclusive, as there were differences in the relative dimensions of the axles experimented upon; he would suggest another series of trials, upon a larger number of axles, as the subject was one of great importance, not only to manufacturers, but to the public, whose safety in travelling depended upon the goodness of the axles under the carriages. He had used upwards of 5000 axles made by the Patent Axle Company, and had made many experiments by breaking them; the average result was equal to that quoted by Mr. York. He agreed in the danger arising from overheating iron, as also from over-hammering it, and for some time past he had caused all the axles to be made 6 inches longer than was necessary, in order to cut 3 inches off each end, to try the quality and the appearance of the fracture of the iron.

The President remarked, that there could not exist a doubt as to the greater strength of a hollow axle, as compared with a solid one; both containing the same weight of material; the principal question to be considered was that of vibration, and its effect upon the cohesive strength of the metal, whether the action upon the particles was more irregular in the solid body, and more distributed in the hollow one; he recommended this investigation to some of the mathematicians who were present; the result of their inquiries might materially aid in the development of truth from the practical experiments.—[*Trans. Inst. Civil Eng.*]

Lond. Journ. Arts & Scien.

Flying Machines. By John Bishop.

We are not destitute of data for estimating the force which is called into action in order to sustain, and keep in motion in the air, bodies, more or less heavy; sufficient has, at least, been done to enable us to form some conjecture respecting the probability of the success of Mr. Henson's machine. An elaborate memoir, on this subject, by M. Chabrier, has been published by the Institute of France, in which will be found a profound mathematical inquiry into the conditions necessary for the movement of machines in the air. In Dr. Todd's Cyclo-

pædia of Anatomy and Physiology, part 23, article *Motion*, I have contributed a number of illustrations, by ascertaining the weight of various insects, bats, and birds, and the amount of surface in each respectively. I have also computed the number of strokes made in a second by the wings of the rook and the pigeon during flight. It appears that the average weight of the pigeon is 4347.344 grains; that of the rook 4170.25 grains; and that of the canary 229 grains; whilst the areas of their wings are respectively 0.6198, 1.11, and 0.054 of a square foot. Hence, we see that the areas of the wings of birds do not vary as their weight; and that the rook has nearly half a pound weight to the square foot, and the pigeon one pound; the former making two, the latter three, effective strokes of the wings in a second. The weight of the former is, therefore, greater, that of the latter less, in proportion to the surface presented to the wind, than in Mr. Henson's machine.

It must, however, be borne in mind, that in this machine the surface presented to the wind has no motion like the wings of birds, neither does the machine possess the power of ascending vertically. In birds, on the contrary, according to Borelli,* the power of the muscles which move the wings, compared with their weight, is more than 10,000 to 1; whilst their mass, compared with the muscles moving the legs, is as 3 to 1. We agree with M. Chabrier, that the amount of force requisite for ærial progression is so enormous, owing to the rarity of the atmosphere, that it would be impossible for a man to sustain himself in the air by his muscular strength alone, in any manner, in which he is capable of applying it. For example, it is calculated that a man can raise 13.25 lbs. avoirdupois, to a height of 3.25 feet in a second, and that he can continue this exertion for eight hours in a day. In that space of time he will, therefore, exert a force capable of raising 381,600 lbs. to a height of 3.25 feet, or 45,700 lbs. to a height of 26 feet, which, according to M. Chabrier, is the height to which the swallow would raise itself in a second of time, by the force which it is obliged to exert in order to sustain itself in the air. Now, if we suppose the conditions, necessary for flight in man, to be the same as in birds, and that a man whose weight is 150 lbs., could concentrate the muscular power of a day's labor into as short a period as the accomplishment of the object required, the time, t, during which he would be enabled to support himself in the air would be,

$$150\,t = 47{,}700;$$

hence, $t = \frac{47700}{150} = 318''$, or about five minutes.

The surface of the wings in the rook and the pigeon when expanded, will not support them stationary in the air, unless they move with rapidity; for when the wings of the rook are expanded motionless in the air, the bird descends by its own gravity with considerable velocity; and as it has a greater surface, compared to its weight, than Mr. Henson's machine, it follows that the latter would be precipitated

* De Motu Animalium.

to the earth with still greater velocity, should the propelling apparatus get out of order in its transit through the air.

It appears by M. Chabrier's analysis, that the quantity of force expended to keep a body, whose weight is W, stationary in the air, (all other conditions being supposed the same,) is as $\sqrt{W^3}$ directly, and $\sqrt{\text{density of the air}}$, inversely. I have, however, elsewhere shown that the quantity of force employed for this purpose, by some birds, is rather less than that here stated.

Lond. Mech. Mag.

Description of Lieutenant D. Rankine's Spring Contractor. By Wm. John Macquorn Rankine, Assoc. Inst. C. E.

This paper describes a contrivance for suiting the action of the springs of railway carriages to variable loads, so as to give the proper ease of motion to a carriage when heavily laden, and at the same time to be sufficiently flexible for light loads. Its effect is to make the strength and stiffness of the spring increase in proportion to the load placed upon it. Each extremity of the spring, instead of supporting a shackle, or roller, as in the usual construction, carries a small convex plate of cast-iron. The form and position of this plate are so adjusted, that when the carriage is unloaded, it bears on the extreme end of the spring, thus allowing it to exert the greatest amount of flexibility; but as the plate is convex, the more the load increases, and the further the ends of the spring descend, the nearer does the point of bearing of the plate upon the spring, approach to the centre, or fulcrum, so that the convex plate, or contractor, tends to diminish the virtual length of the spring in proportion to the load, the result of which is to increase the strength of the spring in the inverse ratio of its virtual length, and its stiffness in the inverse ratio of the cube of the same quantity.

The author then gives in a tabular form, the details and the results of some experiments made on springs of this description, which are similar to those now in use on the Edinburgh and Dalkeith Railway. The springs were 4 feet long, each consisting of ten plates, each ¼ inch thick, and 2¾ inches broad. The contractors were cast with a radius of 12¾ inches, and so constructed as not to act until the load on each spring exceeded 10 cwt., and with a load of 30 cwt., they should have contracted the distance between the bearing points to 3 feet 4 inches, instead of four feet; by this means the strength of the spring was increased in the ratio of 6 to 5, and its stiffness in the ratio of 216 to 125.*

The advantages stated to be derived from the use of these springs on the Edinburgh and Dalkeith Railway, and other lines, are—That

* Since this communication was made, contractors of great length, and increased radius of curvature, have been applied, so as to produce a contraction of 6 inches at each end of the spring when fully loaded, which increases the strength in the ratio of 4 : 3, and the stiffness in that of 64 : 27. The details of the construction of these contractors, with a drawing of them, as applied to the springs of the carriages on the Edinburgh and Dalkeith Railway, are given in the addendum to the original paper.

they afford the same ease of motion to a single passenger, as to forty or fifty in one carriage; they save wear, both of carriages and railway track; they produce the strength and stiffness requisite for the maximum load with less weight of metal; they are not more expensive than rollers; and they are not offensive in appearance, indeed, they would not be observed unless they were pointed out.

Ibid.

On an application of the Electrotype Process, in conducting Organic Analysis. By ROBERT MALLET, Ph. D.

An application of the electrotype process has been made by me, which appears of some value to those engaged in the pursuit of organic analysis; I therefore hope a brief notice of it may not be out of place in the Philosophical Magazine. When very high temperatures are required to effect, or complete, difficult combustions with oxide of copper, or chromate of lead, as in the determination of carbon in certain varieties of cast-iron (which indeed suggested the application to me,) the glass tube is liable to soften and get distorted, though of Bohemia glass, and it has been usual to cover it by lapping a spiral strip of thin copper round the tube. This, however, is never in close contact, even when cold, and the tube is liable to be broken either in the lapping, or during the combustion.

The method I have now to mention as a substitute for this, consists in brushing over the outside of the combustion tube with a very thin coat of Canada balsam and turpentine, dusting it over with fine powder of plumbago which adheres thereto, connecting one end of the combustion tube with a copper wire, and plunging the whole into a cell of sulphate of copper, in the common electrotype arrangement. In a few hours the whole exterior of the tube is found covered with a perfect, close, and coherent jacket, or tube of copper, and may now be at once put into use.

The copper covering adheres so close to the glass tube, and is so completely itself an *air-tight* combustion tube of copper, that should the glass tube crack in the combustion, it is of little importance.

The film of Canada balsam between is so indefinitely thin, that its decomposition has no injurious effect. A combustion tube of 18 inches long is only increased in weight about $\frac{1}{10}$th of a grain by this coating, when dry (without the plumbago of course.) For the latter, Dutch gold-leaf may be substituted with advantage.

The glass combustion tube is best filled with the oxide of copper, &c., and subject of analysis, before the precipitation of the copper upon it, and the tube is best drawn out to a neck at the end next the kali apparatus, as well as at the remote one, the former being done immediately after the filling; the latter neck is opened on commencing the combustion, and the union with the train of absorbent vessels is made by cork in the usual way, but in inverse order, that is, the first cork is not inserted *into* the combustion tube, but placed *upon* the drawn-out neck, thus—

The whole tube from A to B, being covered with copper, the passage for the gases is insured by a sharp blow or two on a table of the combustion tube as usual.

In the methods proposed by Professor Bunsen, of Marburg, some time ago, chiefly for the determination of nitrogen by combustion in a hermetically sealed tube, he imbedded the combustion tube in a mould of plaster of Paris, to prevent the elastic gases evolved from bursting the tube. The process was difficult and uncertain, but the application of the method above described, gives as much facility to the performance of organic analysis by this method, as by any other.

This mode of precipitating copper upon glass, is also susceptible of many other useful applications, in the arrangement of chemical apparatus, when heat, or pressure, is concerned.

Lond. Edin. & Dub. Philo. Mag.

On a method of Etching on Hardened Steel Plates, and other Polished Metallic Surfaces, by means of Electricity. By J. H. Pring, M. D.

I herewith transmit to you a rough specimen of what I conceive to be a novel employment of the power of electricity, and shall be gratified, should the process by which it was effected, prove susceptible of any useful application to the arts.

The method which I employed in the production of the characters on the accompanying plate,* was the following:—Having six batteries of the kind invented by Mr. Smee, the platinized silver plate of each being about three inches square, I attached the steel plate to be etched upon, to the zinc extremity of the batteries, a coil of covered wire, of considerable length, being previously interposed between the steel plate and the zinc: then taking the wire connected with the platinized silver in my hand, I used it as an etching-tool on the steel plate—an electrical spark of great brilliancy, accompanied by a slight indentation on the steel, was the result of each contact of the wire with the plate.

The wire by which the etching was made was of platina; the part at which it was held, was carried through a glass tube for the purposes of affording a more convenient handle, and of protecting the hand from shocks to which it might otherwise have been exposed.

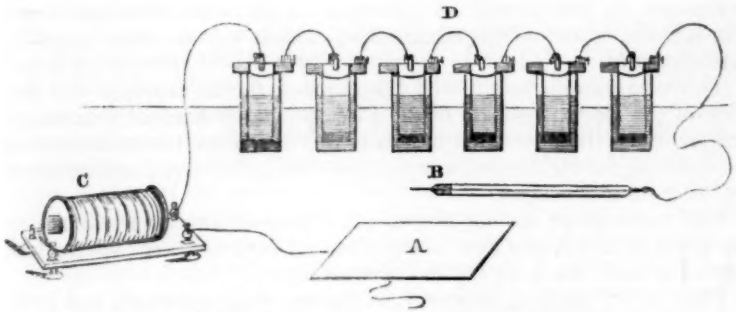
By using the wire connected with the zinc of the batteries as the etching-tool, and attaching the steel plate to the platinized silver, a very different effect is produced. With the apparatus thus arranged,

* This was a steel plate, on which the words "Etched by means of Electricity. Bath, 30th June, 1843. J. H. P." together with some ornamental devices, had been produced by the above method. It gave only a faint, just legible impression, by the copper-plate press.—Editor.

the spark that results from the contact of the wire with the steel plate, is accompanied by a deposition of a minute portion of the substance of the wire on the steel; by using different wires, therefore, as of gold, silver, platina, &c., a variety of ornamental designs may probably be formed on polished steel surfaces.

The effect of the electrical agency here described, is not, however, confined to steel; a somewhat similar one may be obtained by substituting plates of other metals. By augmenting the quantity and intensity of the electrical current, it seems probable that the effect on the steel, or other metals, would be proportionally increased; and it may be anticipated that, by other modifications of the process, its applications may be advantageously extended.

The accompanying sketch, in which the apparatus is represented lying ready for use, may, perhaps, serve to illustrate the foregoing description.



A, the steel, or other metallic, plate to be etched upon.
B, the etching point of platina wire projecting from the glass handle.
C, the coil of covered wire.
D, the batteries.

Ibid.

On some Experiments made by a Commission of the Royal Institute of the Pays Bas, with a view of verifying the property ascribed to Oil, of calming the waves of the Sea.

The Annales de Chimie et de Physique, for the month of March, 1842, contain a Memoir, by M. A. Van Beek, on the property possessed by oils of calming waves, and rendering the surface of the water perfectly transparent. After citing many testimonies to prove the existence of this property, and its efficacy, the author goes on to express the opinion that we may find, by the use of oil during tempests, a means of protecting piers, and other marine constructions, against the violence of the waves, by pouring it on the water not far from the sides.

So bold and singular a supposition could not fail to attract the attention of men of science; accordingly, the Academy of Sciences of Paris appointed a commission to examine the subject. But, on this

occasion, it will be neither useless, nor uninteresting, to our readers, to know that the same question has already been agitated in Holland.

M. Van Beek, who is a member of the Royal Institute of the Pays Bas, made a proposal last year at the sitting of the class of sciences, having for its object to prevail on the government to institute experiments with the view of proving that oil had the power of preserving piers against the violence of the sea.

This proposition was not generally approved of. Three members were chosen to examine further into its importance; but these three persons in their turn being by no means unanimous in the considerations and advice which they offered, it was thought that the best way of getting rid of the embarrassment, was to adjourn the consideration of the proposal, and endeavor, before resuming it, to obtain some positive light on the question itself. In consequence, a commission of five members was appointed, with instructions to make direct experiments on the power oil exercises on the waves near the coast: and it is the report of this commission which we are now about to communicate.

The commission nominated from among the members of the first class of the Royal Institute of the Pays Bas, and directed to make experiments on the power attributed to oil, and other fat substances, of diminishing the violence of waves, report what was done and observed by them on this subject.

The commission having chosen the village of Zandvoort, situate on the shore of the North Sea, as the place for making their experiments, agreed to meet there on the first stormy day.

They were obliged, however, to change their intention, and to fix on a certain day, on account of the period of the season (the month of June,) during which tempests are rare; and the blasts of wind of any degree of strength being also of short duration, it would have been impossible for them to have met at the village mentioned in proper time. They came more readily to a decision by considering that, if oil really exercises on the water, in a state of great agitation, the power supposed, it must be still more easy to recognize this property on a sea put in motion by a wind of moderate force. Meanwhile, two of the commissioners, happening to be in the country on a day when the wind was blowing violently, made a trial by pouring a small quantity of oil on the water of a rivulet, and observed an evident change in the appearance and movement of the water.

Another member of the commission made, on the same day, a similar trial on the Spaarne, (a small river near Hærlem,) and obtained the same result.

Encouraged by all these observations, the 28th of June was fixed on for the purpose of proceeding to ulterior experiments.

The commissioners assembled at Zandvoort on the day mentioned, at nine o'clock in the morning. Some of them proceeded a short distance from the shore, in order to pour the oil upon the water, and observe the results; the others remaining on land, and not knowing either at what moment, or how many times, the oil was poured out,

were to keep their eyes fixed on the waves, which rolled from the boat towards the shore; by these means, their opinion, exempt from all influence, might be considered as so much the more impartial.

The wind was south-west, and of moderate force; the quantity of oil poured out at four different times, namely, at 43, 45, 50, and 54 minutes past nine o'clock, amounted to 15 litres (upwards of 3 imperial gallons); the tide was flowing, and would not reach its full height till 21 minutes past eleven o'clock.

The commissioners who remained on the shore, not having remarked any effect which could be ascribed to the effusion of the oil, and the same thing being the case with those engaged in pouring it, we might already consider the question, if oil poured at a little distance from our piers could protect them from the fury of the waves, as answered in the negative. Nevertheless, the commissioners thought it incumbent upon them to make a second trial at a somewhat greater distance from the shore. Two of them were rowed beyond the rocks, and then cast anchor.

The distance was calculated by the boatmen at 300 yards; the sounding line indicated a depth of about three yards; and the waves were rolling considerably. More than the half of 15 litres of oil was poured out in the space of five minutes (from 15 to 10 minutes before 12 o'clock,) and the commissioners did not observe the slightest effect in relation to the object of their mission. They saw the oil swimming on the surface of the water, partly united in spots of an irregular form, partly extended, and forming a pellicle, and partly mingling with the foam of the waves, and sharing in their oscillatory movements.

When returning to the shore, at the moment of passing the rocks, the commissioners caused the rest of the oil to be poured on the water, and they can testify that it had no effect in diminishing the motion of the waves, for they were many times abundantly sprinkled with the spray. It is unnecessary to add, that those who remained on land, had remarked nothing at all which could be attributed to the effusion of the oil.

After all that has been said and written on this subject, the commissioners are astonished at the negative result of their experiments, and, limiting themselves to the account of them, they add no observations. They believe themselves, however, authorized to assert, as their personal opinion, that the idea of protecting our piers by means of oil, is not a happy one.*

Edin. New Phil. Journ.

Tides at Otaheite.

That it is invariably high water at noon, at the island of Otaheite, has been a received fact ever since the days of Cook; but it now appears, from a tide journal kept at the harbor of Papeete, by Mr. Richardson, R. N., and communicated to the Royal Society by Capt. Sir Edward Belchor, that this is not correct—though, certainly, the

* From Annales de Chimie et Physique. T. vii. p. 371.—The experiments appear to have been conducted on too small a scale to afford satisfactory results.—Editor.

cause of the tides at this island do present some anomalies very difficult to account for. "By a reference," says Sir Edward, "to the tide registry annexed, it will be found that there are two distinct periods of high water, during each interval of twenty-four hours; and that during the seven days preceding, and seven days following, the full and change, they are confined between the limits of 10 A. M., and 2h. 30m. P. M., the whole range of interval, by day, as well as by night, being about 4h. 27m. Commencing with the seventh day preceding the full moon, viz., the 9th of April, it will be perceived that high water occurs at 10 A. M., this being the greatest A. M. interval from noon; and that on the 16th, at the full moon, it occurs nearly at noon. Passing on to the 23rd, it reaches the greatest P. M. limit at 2h. 30m., and on the second of May it again reaches the noon period. Between the 23rd and 24th, however, a sudden anomaly presents itself; throughout the day of the 23, the variation of the level does not exceed 2½ inches, and the general motion is observed to be 'irregular.' The time of high water is also the extreme P. M. limit. On the 24th we discover that it has suddenly resumed *the most distant* A. M. *period*, viz., 10 A. M., but proceeds regularly to the noon period at the change. Although the differences of level do not, at full and change, exceed 1 foot 4½ inches, still, I presume, that we have sufficient data to establish the fact, that it is *not invariably high water at noon* (as asserted by Kotzebue, Beechey, and others:) and, further, that we have corresponding *nightly periods* of high water. It is evident that the time of high water at full and change may be assumed as that of noon, because we have sufficiently decided changes of level to fix the approximate period of high water. It does not appear by these registers, that any higher levels result from the rollers sent in by the strong sea breezes, (as asserted by several writers,) but rather the contrary, the highest levels being indicated during the night, when the land breezes prevailed."

Lond. Mech. Mag.

GLEANINGS FROM FOREIGN JOURNALS.—No. 1.

New mode of measuring the depth of the Sea.—M. Aimé describes an apparatus for sounding, in which a weight attached to the line, may, on reaching the bottom be detached, so that the line is drawn up with very slight resistance. He has affixed to this apparatus a vessel for collecting water at different depths, and made, at Algiers, a series of experiments at various distances from the surface, from about 350 to 2200 yards, from which he infers that the amount of gas absorbed by the water, at different depths, is nearly the same, and that the saline constituents are likewise uniform in quantity.

Ann. de Chim. et de Phys.

On Galvanic Induction.—M. Abria, Professor in the Faculty of Sciences, of Bordeaux, has repeated and varied the experiments of

Professor Henry, of Princeton,* on the inductive action of a galvanic current, confirming the laws already deduced. Ibid.

Resistance of Earth to the motion of Electricity.—Prof. Jacobi concludes, from his experiments, (Bulletin of the Petersburg Academy, vol. i.) that the resistance of earth, the surface of the ground, to the motion of galvanic electricity, may be considered as nothing, and hence that it may be used to form part of a circuit in telegraphing.

Poggendorf's Ann. March, 1843.

Another new Metal.—Mosander has discovered a new metal associated with cerium, lanthanun, and didymium, in Gadolinite.

Chem. Gaz. Aug. 1843.

Elasticity, &c. of Alloys.—The experiments of M. G. Wertheim show that, 1. In alloys of metals the less the distance of the molecules, the greater the elasticity of the alloy. 2. The coefficient of elasticity of alloys generally, may be calculated from the coefficients of the components. Certain alloys of zinc and copper are exceptions to this rule. 3. The tenacity, limit of elasticity, and tensile power of alloys, cannot be determined from similar particulars in regard to their constituents. 4. Alloys resemble pure metals, in reference to their transverse and longitudinal vibrations, and to tensile power.

Compte Rendu of Acad. Sc. of Paris, May, 1843.

Action of Water on Bodies.—When water dissolves, cold is produced, this is shown by Peltier, by the action on the galvanometer through a thermo-electric current; when water combines, chemically with a body, heat is produced. When water is exposed to electrolization, hydrogen is condensed about the negative electrode, and oxygen near the positive, and if the ends of the wires of a galvanometer be plunged into any part of the fluid, except the middle, a current will be developed from the unequal distribution of the gases.

Peltier in Compte Rendu, &c.

Heat from Comets.—M. Ad. Mathiessen found sensible heat from the zodiacal light, by the aid of Melloni's thermo-electric arrangements. He could detect none in the light from the tail of the great comet of 1843. Ibid.

Speaking Machine.—A machine capable of emitting sounds resembling the human voice, has been exhibited lately at Berlin. The inventor is from Vienna, and named Taber. The sounds of the different letters may be produced separately, or in combination. The voice is also susceptible of modulation.

Poggendorf's Ann. Feb. 1843.

Thermo-electric from Hydro-electric currents.—Poggendorf gives a simple way of proving that a galvanic current passing through the junctions of dissimilar metals, produces a thermo-electric current in the same direction, and with the same electro motive force as its own. One pole of a thermo-electric battery is connected with one pole of a

* Amer. Philos. Soc. Trans. Vol. viii.

galvanic battery, and with a galvanometer; a wire from the other pole of the thermo-battery is made to touch alternately, for an instant, the other pole of the galvanic battery and the galvanometer, so that the force which acts upon the galvanometer needle, is alternately that of the hydro-electric current, and of the thermo-electric current produced by it. The needle of the galvanometer continues its motion, and reaches the same point that the hydro-electric current would have carried it to, had it acted the whole time. Ibid.

Professor Knorr, of Kasan, in his experiments on the cause of the images produced on metallic plates by coins and similar articles, found the following significant result. When the temperature of the air was between −8 and −19° Fahrenheit, an engraved copper plate was placed upon a polished plate, and left there from six to twenty hours. The vapor of iodine brought out no picture on the polished surface, while breathing on similar plates which had been in contact at a temperature of 66° Fahrenheit, sufficed to show an image.

Poggendorf's Ann. April, 1843.

Amalgam of Sodium in a Galvanic Pair.—F. C. Henrici substituted an amalgam of sodium for zinc in a galvanic pair on a Daniell's constant battery. The amalgam readily adhered to a brass wire so that the exchange for a zinc cylinder was easy. When a very small mixture of sulphuric acid and water was used as the exciting liquid about the zinc, or amalgam, cylinder, the following results were obtained. In ten minutes with the zinc cylinder, 7 parts of gas were collected in a voltameter, with the amalgam cylinder 92. In twenty-three minutes, 265 with the amalgam cylinder; in forty-five minutes, 34 with the zinc. In 208 minutes the decomposition, when the zinc cylinder was used, amounted to 237 parts, or less than the result in twenty-three minutes with the amalgam cylinder. With a saturated solution of common salt, instead of the dilute acid, the results were in five, ten, and fifteen and one-third minutes, when the amalgam cylinder was used, 115, 190, and 265 parts, and in five and ten minutes, respectively, with the zinc cylinder, 38 and 62 parts. With a stronger mixture of sulphuric acid and water, the amalgam cylinder gave 30 parts in one minute, and the zinc 51½ in ten minutes.

Ibid. Feb. 1843.

Jupiter's Moons.—A Japanese Encyclopædia published prior to A. D. 1713, gives, according to Libri, a figure of the disk of the planet Jupiter, accompanied by two small stars, and the text states that they appear to be connected with (as it were dependants on) the planet.

Ibid.

Level of the Caspian.—M. Hommaire Dehel finds, by leveling along the streams emptying into the Sea of Azof, on one side, and into the Caspian, on the other, that the Caspian is 18,301 metres (about 20,000 yards) below the Sea of Azof. He denies that the Caspian is the centre of a depression sui generis, but concludes that it occupies the lower part of a basin which the sea once filled.

Compte Rendu of Acad. Sc. of Paris, 1843.

Images on Resin.—When an electric discharge is passed through

a coin placed upon a cake of resin, the base of which communicates with the ground, the part of the cake impressed separates minium from a powder of sulphur and minium rubbed together, and thrown in dust upon the surface. (Masson.) Ibid.

Images on Glass.—M. Karsten states that if an electric discharge be passed through a coin placed upon a glass plate, an image is impressed on the glass, which may be rendered visible by the vapors of iodine, or mercury, or even by breathing upon it. Ibid.

Corona and Beads during a Solar Eclipse.—The appearance of the *corona*, or glory, which surrounds the moon during the time of total darkness in a solar eclipse, and the *beads* which occur prior to the period of total obscuration, and also in annular eclipses, have been imitated by Professor Baden Powell, in the following manner:—A candle is placed in the focus of a lens, placed in a screen, with an aperture of about three quarters of an inch in diameter; on the opposite side of the screen is placed an opake circular disk, of a diameter equal to, or greater, than the aperture, which may be placed at different distances, so as to produce an eclipse of any magnitude, as the spectator changes his position. When the eclipse is total, the glory is seen, and when there are cusps, the beads are seen.

Lond., Edin. & Dub. Phil. Mag., July, 1843.

Electricity from Steam.—Professor Farraday has successfully traced the electricity from steam to the friction of particles of water against the exit pipes. Wood is the best material for the nozzle, when it is intended to show the production of electricity by the escape of steam. The source of lightning cannot be, in his view, the condensation of vapor. Ibid.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Hasty Generalizations in Science.

To the Committee of Publications:

Gentlemen,—At this time, when scientific investigation is going on with so much activity, a proneness to hasty generalizations appears to prevail in many quarters, calculated to injure, rather than serve, the progress of science. Regretting to see a spirit of this sort in a writer, often appealed to, on the important questions of meteorology agitating at the present time, I send you a brief notice of a recent paper by him, in Poggendorf's Annals, with the hope that you will send the number of your journal to Berlin, that he may see how such things look in *abstract*.

Meteorological Deduction.—Professor Dove, of Berlin, has the following assertion in a recent meteorological paper, read before the Academy of Berlin, and published in Poggendorf's Annals. "The peculiar relation [of distribution of temperature] belonging to continents, is not to be found in America." Then is America not a continent, or else the relations to which the Berlin philosopher refers, are not peculiar to continents. The same philosophical spirit is manifested

in Professor Dove's remarks in regard to Mr. Espy's theory of storms: "and as Espy has done, see an upward current as draught-leader (zugführer) at the top of a whirlwind, but a glance merely at the storm-charts of Redfield and Reid, is sufficient to show how unnatural the supposition is." Important questions of meteorology dependant upon a glance at a chart, and American meteorology not continental. The journals quoted in the course of the paper, are Captain Parry's at Melville Island; "Ancasters, between Ontario and Erie," of five years Observations at St. Johns, Newfoundland; and of Observations at Cambridge, Massachusetts. The sweeping conclusions from such insufficient data suit well with the neglect of numerous published registers of authority, but the extraordinary selection of localities from which to form a judgment, could hardly be expected from any one claiming to be a meteorological authority.

M. Clement's Nautical Inventions.

On the Sillomêtre, Sub-Marine Thermometer, Steam Indicator, Derivomêtre, and External and Internal Thermometer.—Communicated by Captain Washington, R. N.

Before proceeding to give a description of these instruments, and particularly of the Sillomêtre of Mons. L. Clément, of Rochefort, some account of which appeared in the May number of the Nautical Magazine, it may be as well to state briefly what has been done in former times, as to finding a substitute for the common log, which it must be confessed, is a sufficiently primitive method of measuring the speed of a ship.

1. It is said that as far back as the time of Augustus, it was proposed by Vitruvius, to pass an axle, or shaft, through the side of a ship, having a wheel at each extremity; from the inner wheel a stone fell at each revolution, and the number of stones determined the rate of the vessel's speed.

2. The Marquis De Poleni, who gained a prize from the French Academy for his invention, about the year 1720, proposed to tow a globe at the end of a long line, connected with a lever, which raised a weight at its other extremity, and pointed out the speed on a graduated arc.

3. M. Pitot proposed a machine composed of two glass tubes, the lower end funnel shaped, and bent towards the ship's head, in which the water rose according to the rate of the vessel's going.

4. M. Saverien proposed a globe about four feet below the surface of the water fixed at the end of a long lever, the upper end to raise weights according to the degree of tension, and thus give the rate.

5. The *Marine Surveyor* of Henry De Saumerez, of Guernsey, on being towed astern of a ship, acquired a rotary motion which was communicated to a machine of clock-work on board, whence the rate was shown on a dial.

6. Russel's *Perpetual Log* was a spiral machine towed astern much on the same principle as that of De Saumarez.

7. Foxon's *Log*, also perpetual, was very similar.

8. The *Navivium*, by Joseph Gilmore, was composed of a wheel and pinion fixed to the keel of a ship; its movement was communicated to clock-work within, by means of a metal rod.

9. Gotlieb's *Perpetual Log* is an instrument nearly similar, with the addition of a box to guard the exterior wheel-work.

10. The *Nautical Dromometer*, of Benjamin Martin, is an instrument of the same kind, only to be fixed to the side of a ship.

11. Hopkinson, of Philadelphia, proposed a metal lever, with a circular plate at the lower end, against which the water acted, and was regulated by a spring, an index showing the rate of the ship in degrees on a graduated arc.

12. Bouguer, the companion of De la Condamine, in his voyage to Peru, proposed a globe, of 6 or 7 inches diameter, to be towed astern, the other end of the towing line to be connected with a lever which should raise weights according to the rate of sailing.

13. The *Hydroscope* of Count De Vaux, proposed in 1803, consists of one or more globes of six inches diameter sunk in the water, level with the keel, passing through a vertical copper pipe, as near the centre of gravity of a ship as may be; the globe is connected by a brass chain with the end of a horizontal lever, the other end of which communicates with a brass slide attached to a spiral spring; this spring is intended to measure exactly the force of the resistance the globe meets with in passing through the water, which is rendered into knots on a dial, and thus shows the rate of a ship's sailing, or the rate of current when at anchor.

14. An addition to this instrument, by the Count De Vaux, was to show the amount of distance run, by a comparison between two clocks, or, as he preferred, a *clepsydra*, or sand glass, which ran out once in 60 miles, when it required to be refilled; this machine would give the whole distance run, as well as the rate of sailing.

[Captain Beaufort carried out the former of these two plans, we believe, and had it fitted to his boat, during his well known and admirable survey of the coast of Karamania, in 1812.]

15. Massey's *Patent Log*, on the same principle as the Marine Surveyor of De Saumarez, is too well known to need a description, and as far as our experience goes, shows the distance run correctly.

16. The *Marinodometer* of Captain Arthur Bingham, R. N., which, in 1824, he fitted to the keel of the Tourist steamer, was somewhat similar to the *Navivium* of Gilmore, as far as we can learn.

17. A plan not unlike that of M. Pitot, (No. 3) was fitted to the Rhadamanthus steamer, Captain George Evans, R. N., in 1830, we believe, but was not found to answer.

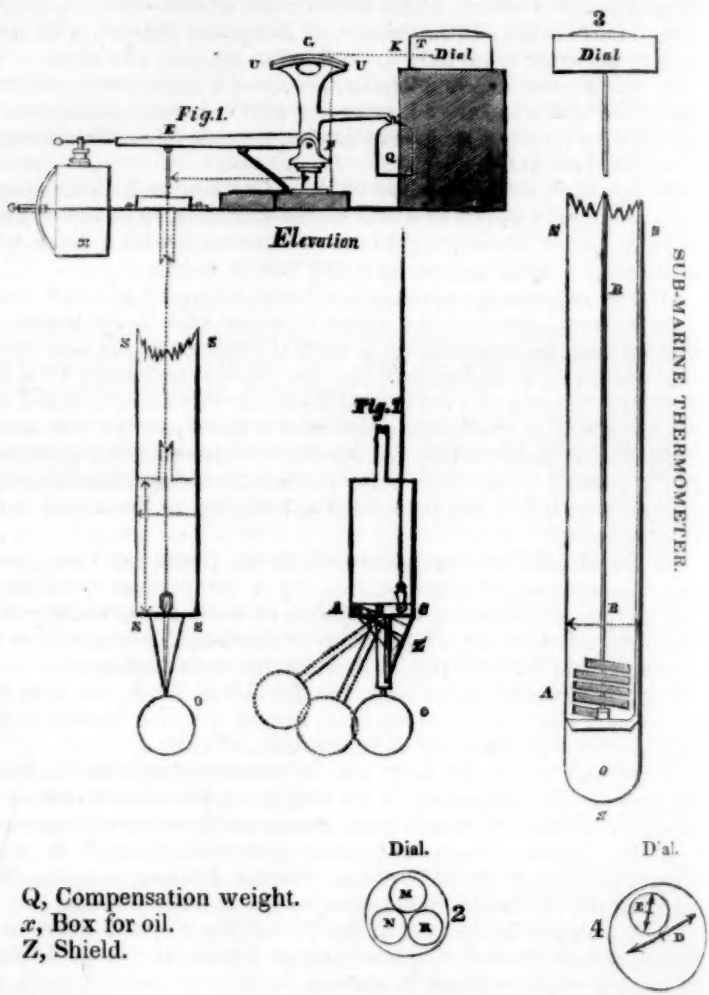
18. Mr. Purcell, of Hamburgh, in 1841, proposed a square plate, or vane, to be fixed under water at the lower end of a metal rod, the upper end connected with a spring; the amount of torsion is shown on a dial by an index.

19. Ayre's *Patent Log* consists of a small pear-shaped ball towed astern at the end of a line, the other is carried over a heavy roller

which it turns according to the amount of tension, an index showing the resistance in knots.

Lastly. The *Sillomêtre* of M. Clément, which we now propose to describe in detail.

Sillomêtre.



Q, Compensation weight.
x, Box for oil.
Z, Shield.

The name, *Sillomêtre*, is composed of the two French words *Sillage* (headway,) and *mêtre* (measure,) and might be well rendered in English, speed-gauge. This instrument consists of a hollow copper ball, fig. 1, about five inches in diameter, suspended under the ship's bottom, nearly amidships, from the middle of a bent lever, A, C, about five inches long; one end of this lever moves on a joint, A, its ful-

crum, attached to the lower end of a metal rod which passes vertically through a copper tube, carried from the deck through the bottom of the ship near the keel; at the other end of the lever is attached a chain, C, which leads upwards, and acts upon a second horizontal lever, E, F, on deck. This second lever corresponding to the lower one, gives motion, by means of a spring, to an index, which marks on a dial, the speed of the ship expressed in knots, and tenths of a knot.

Such is the whole of the apparatus of the simple Sillomêtre. It will be readily understood, that, as the vessel moves through the water, the fluid acts upon the ball, which being circular, always presents the same section, and causes it to move aft, thereby depressing the fore end of the lever, which, by the chain, communicates with the dial on deck. The scale, by which to graduate the knots on the dial, was found by M. Clément after numerous experiments. This instrument in its simple form, shows the speed of the vessel, not the amount of distance run.

The Compound Sillomêtre consists of the same mechanism, with this addition, that the power which moves the index is applied at the same time to a watch, and accelerates its movements in proportion to the intensity of the moving power, or as the vessel quickens her speed.

A second watch is placed by the side of the first, in order to show how much the former gains upon the latter; and knowing that for every 6 seconds of gain, the vessel will have made a mile, it is easy to know the distance run.

It is evident that this compound instrument is very superior to the simple one, but its accuracy depends upon the regular going of two good watches, a result not very easily obtained at sea.

The *Sub-Marine Thermometer* is a very delicate instrument composed of a ribband formed of two metals of unequal contraction and expansion, as platina and silver, and rolled in the form of a helix, A, fig. 3, round an axis, B, which turns as the temperature of the water varies. This motion by a train of wheels and pinions is immediately communicated to two pointers on a graduated dial on deck, and which may be read off easily to hundredths of a degree.

The whole of this apparatus is enclosed in a metal tube, which passes through the bottom well aft in the run of the ship. The helix, or thermometer, is, therefore, always at a certain depth in the water, say 10 feet below the surface; and it shows instantly every change in its temperature.

As few observations have been regularly made on the temperature of the water of the sea at a certain depth, this machine may lead to some novel results.

The *Steam Indicator* points out the temperature and consequent pressure of the steam in the boilers. It is composed of a ribband, or blade, of two sensitive metals of unequal expansion, turned in a spiral form; one end is fixed to the tube, or pipe, in which it is contained, the other connected with a spindle bearing the pointers which indicate the temperature of the steam on a dial on deck, in degrees and tenths

of a degree. This instrument is connected, by a small pipe, with the boiler, or steam chest, through which the steam reaches the spiral, which instantly causes any variation in temperature to be shown by the dial on deck: in high pressure engines this may be found useful.

The *Derivometer* is an instrument somewhat on the principle of the Sillomêtre, and intended to measure the drift of a ship; this is done by a vane placed on the keel, connected by a rod with a dial—the vane, of course, takes the opposite position to the drift of the vessel, which is communicated by the turning of the rod to the pointers on the dial on deck.

The *Internal and External Thermometer*, as its name indicates, is a highly sensitive thermometer, so placed against the wall of an observatory, or house, as to show the temperature of the air within and without. The two pointers, which mark this, are on the face of the same dial.

We believe that Her Majesty has ordered such an instrument to be placed in one of the apartments in Buckingham Palace.

We now proceed to the trial of the first named three of these instruments, as fitted on board H. M. S. *Blazer*, in April last.

REPORT.

Monday, 3rd April, 1843.—H.M. steam vessel *Blazer*, having been fitted with three newly-invented instruments by M. Clément, of Rochefort, namely, a Sillomêtre, to measure the rate of speed,—a Steam Thermometer, to indicate the temperature of steam in the boilers,—and a Sub-Marine Thermometer, to show the temperature of the sea at 10 feet below the surface, was directed to proceed down the river, on trial, having on board M. Clément, the inventor, Mr. Cary, who had constructed the present set of instruments, and Mr. Large, of Woolwich Dockyard, who had superintended the fitting of them in the vessel.

Before starting, made a trial under the superintendence of Mr. Lloyd, chief engineer, of Woolwich Dockyard, of the temperature of the steam by the steam thermometer, as compared with the elasticity of the steam, as shown by the steam gauge, at each lb. pressure; making due allowance for the height of the barometer, and using the temperature as given in Dalton's experiments, corresponding to the inches of mercury in the steam gauge. The results obtained were as follows:—

	Steam Ther. Centi.		Inches.
At 5⅞ lbs. pressure, 1st exp.	110.4	Barometer,	29.85
" 2nd do.	110.2	Hei't of steam gauge,	10.25
Mean,	110.3		
Temp. by Dalton's tables,	108.7		40.10
Difference,	1.6		

At 3 lbs pressure, 1st exp.	107.0	Barometer,	29.85
" 2nd "	107.0	Height of steam gauge,	6.00
Mean,	107.0		
Temp. by Dalton's tables,	105.2	- . - -	35.85
Difference,	1.8		
At 1 lb. pressure, 1st exp.	103.3	Barometer,	29.85
" 2nd "	103.3	Height of steam gauge,	2.00
Mean,	103.3		
Temp. by Dalton's tables,	101.7	- - - -	31,85
Difference,	1.6		
At 4 lbs. pressure, 1st exp.	108.4	Barometer,	29.85
" 2nd "	108.4	Height of steam gauge,	8.00
Mean,	108.4		
Temp. by Dalton's tables,	106.9	- - - -	37.85
Difference,	1.5		
At 2 lbs. pressure, 1st exp.	105.4	Barometer,	29.85
" 2nd "	105.3	Height of steam gauge,	4.00
Mean,	105.3		
Temp. by Dalton's tables,	103.4	- - - -	33.85
Difference,	1.9		
At 0 pres. safety valve open,	101.3	Barometer,	29.85
Temp. due to height of barom.	99.7		
Difference,	1.6		

Tested also the Sub-Marine Thermometer by sinking one of Newman's Standard Thermometers 10 feet below the surface of the water, and keeping it there half an hour, At high water the temperature by M. Clément's Sub-Marine Thermometer was 45°.9; by Newman's Mercurial Thermometer 40°.0. Temperature of air 47° Fahrenheit.

Tried also on shore in the dockyard, by a quadrant, the angles at which the centre of the ball of the Sillomêtre would stand when the index marked different knots on the dial, and found as follows:

The ball left to hang, with the chain loose, being in the position taken in the water when at rest.

The chain tight,	0 deg.	on quadrant.	0	knots on dial.
"	10	"	0	"
"	15	"	2.2	"

The chain tight,	20 deg. on quadrant.	4.5	knots on dial.
"	25 "	6.6	"
"	30 "	8.6	"
"	35 "	10.3	"
"	40 "	11.5	"
"	45 "	12.1	"
"	50 "	12.8	"

Passage from Woolwich to the Nore.

Time.	Rate of going.		Steam Thermometer		Sub-marine Thermom't'r.		Dp. wr.	Tm. air.	Remarks, Monday, April 3, 1843.
P. M. h. m.	Si lom.	Log.	Centi °	Fahrn. °	Centi °	Fahr. °	fm	°	
3 45	5.8		110.5	230.90	9.40	48.92	5½	59	At 3h. 45m. started from Woolwich, moderate breezes and fine; wind
	6.7								
4 0	6.1				9.20	48.56			W.S.W. 2; barometer 29.80.
	6.4	6.2	110.0	230.00	9.25	48.65	6		High water; draught of water forward 11 ft. 4 ins., aft 11 ft. 8 ins.
	6.2								
	6.6		109.6	229.28					Boilers filled with fresh water.
4 15	6.4				9.02	48.04	5¾		Sillomêtre put in action just abreast the Dockyard.
	8.2		110.1	230.18					
	6.0		109.8	229.64					Adjusted the chain to the rate shown by the common log.
	5.5								
					8.85		6¼		Altered the helm continually to
4 30	6.8		110.1	230.18		47.93			avoid vessels in streaming down the river; at each spoke of the wheel the
	5.0								
4 45	7.5		110.1	230.18	8.75	47.75	7½		Sillomêtre showed a decrease of rate,
	6.0		110.7	231.26	8.60	47.48	8		when put hard over the speed fell
	6.2								from 7 knots to 4.
5 0	6.2	6.2	109.5	229.10	8.55	47.39	8½	56	At 4h. 20m. the Sillomêtre showed
	6.6		109.8	229.64					a speed of 8.2, which is certainly be-
5 15	5.9		109.0	228.20	8.48	47.25	7¼		yond the power of the vessel.
5 30	6.2		108.8	227.84	8.42	47.16			At 4h. 30m. put over Massey's Log.
	6.8	7.0			8.30	46.94			At 5h. off Greenhithe. Variations of
	6.9								speed as shown by Sillomêtre, 5.4
									while heaving the common log, 5.6
									" " 5.8
									" " 6.0
									" " 5.6
									" " 5.8
5 45	5.6		108.5	227.30	8.32	46.98	9		
	6.5								Mean, 5.7
6 0	6.2		109.5	229.10	8.30	46.94	7	52	
6 15	6.5		108.9	228.02	8.25	46.85	6½		
6 30	6.0	5.8	109.7	229.46	8.20	46.76	7		At 5h. 45m., in 9 fathoms, the Sub-
	5.8								marine Thermometer indicated no
6 45	6.8		109.4	228.92	8.22	46.80	5½		difference of depth. At 6h. off Sheer-
7 0	6.3		109.5	229.10	8.13	46.64	5½	51	ness. In 2¾ hours, Massey's Log
7 15	6.5		109.7	229.46	8.10	46.58			showed a distance of 21.6, which
	6.4				8.08	46.56			exceeds that given by the Sillomêtre, or common log.
									At 7h. 30m. anchored at the Nore.
									Tried the temp. of water by Mercu-
									rial Thermometer, and found it to
									agree exactly with M. Clément's
									Sub-marine Thermometer, namely, 46°.5.

The Sillomêtre throughout this passage was very sensitive, showing immediately the change of rate due to a single spoke of the wheel.

The Steam Thermometer varied regularly with the temperature of the steam as shown by the steam gauge, but generally stood 3° of Fahrenheit, in excess.

The Sub-marine Thermometer showed a gradual decrease of temperature as we approached the sea, which was unexpected, but it agreed exactly with the best mercurial thermometers.

Remarks.—It will be seen from the above table, that the Sillomêtre showed every variation in the speed of the vessel, even the alteration caused by a single spoke of the helm was perceptible, and putting the helm hard over, caused the ship to lose half her way almost immediately; as the dial of the instrument is placed on deck, and the index, or pointer, very conspicuous, the officer of the watch, without any trouble, may observe it at every turn he takes on the quarter deck; and it is obvious that none but the most inattentive person can fail to have a much more correct knowledge of the rate of the vessel's going, than he can from heaving the common log once or twice an hour. The Sillomêtre will also enable an officer easily to ascertain the best trim of a vessel; the difference caused by shaking out a reef, or by making, or shortening, sail; and in a fleet would enable a ship to keep her station by night, or by day, with great steadiness; and lastly, it impresses very strongly, on the observer, the absolute necessity of good steering, and giving very little helm when in chase, or on a trial of sailing, or at any other time when speed is of importance.

The *Steam Thermometer* has also a dial placed on deck, so that the officer of the watch can tell at any moment whether there is a sufficiency of steam, or the contrary, and can thus check the wasteful expenditure of coal; it would point out, too, the possible, but highly improbable, occurrence of no water in the boilers, or an undue increase of the temperature of steam from any other cause. Its chief value, however, would be shown in a high pressure engine, when it would give, immediately, warning of any approach to such a degree of temperature, or pressure, as might be dangerous.

The *Sub-marine Thermometer* remains constantly at a depth of about ten feet below the surface of the water, and owing to its being formed of platina and silver, is extremely sensitive, and thus every change in the temperature of the sea will be shown at once on the dial on deck.

As in the Atlantic Ocean, and in other deep seas, the deep water is said to be warmer than the shallow, it probably would there show, by mere inspection, the approach to shoals, rocks, or land, and serve as an excellent warning. At this season of the year, however, in the shallow waters of the North Sea, we observed no such effect, on the contrary, the temperature of the water gradually decreased from 50° Fahrenheit, at Woolwich, to 44½°, at about twenty miles to the eastward of the North Foreland, and as gradually increased on our return to the same point.

Possibly as the summer advances this may be different, and, in order to discover when the change of temperature takes place, I have directed the instrument to be registered every two hours night and day. As the Thermometer is highly sensitive, and may be read off with ease to hundredths of a degree, and agrees perfectly with the best mercurial thermometers, it many possibly furnish some novel results of value to the philosopher, as well as to the navigator, since I am not aware of the existence of any continued series of observations on the temperature of the sea, at all seasons of the year.

I would venture to recommend that the instruments, after coming from the hands of the maker, should be put to the severest test by competent persons before being finally placed in a ship.

The instruments fitted on board the *Blazer*, appear to be carefully made and well finished; they are conveniently and securely placed in the ship, nor does there seem to be any fear of their being deranged.

Harwich, April 12th, 1843. Lond. Naut. Mag.

TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Electro Chemical Silvering.

A report made by M. Becquerel, in his own name, and in those of M. Dumas, and Hericourt de Thury, to the Academy of Sciences of Paris, session of July 10th, 1843, upon a communication made by M. Mourey, concerning an useful modification of the processes hitherto used in electro-chemical silvering. Heretofore the articles silvered by the electro-chemical process have been, indeed, when first taken from the apparatus, of a perfect mat-white, which, however, they soon lost, and in a few days their surface became of a dirty yellow, which diminished their value. If we endeavored to color them as in gilding, the silvering was injured. The process of M. Mourey is intended to avoid this difficulty. In electro-chemical silvering, as in all the decompositions effected by means of electricity, the article which is covered with silver attracts to itself, at the same time, all the electro positive elements which are in the solution, so that in the case before us, there is a sub-cyanide of silver, a compound upon which light acts to change its color. The object then is to destroy this compound without the use of acids. M. Mourey has succeeded in this by a very simple process. He covers the articles several times with a solution of borax, and then submits them to a temperature so high that the borax begins to melt, then plunges them into water acidulated with sulphuric acid, and suffers them to remain some time. The articles when washed and dried acquire the most beautiful lustre which virgin silver can take. This lustre remains so long as the articles are not exposed to sulphurous vapors.

Galvanic Bronzing.

M. Becquerel again exhibited to the Academy, new specimens of his metallic applications. In communicating, at the last session, the

process by means of which the peroxides of lead and of iron may be applied to the surface of metals, so as to preserve the oxidizable ones from ultimate injury, he had remarked that it was possible so to vary the colors of the coatings, as to present effects agreeable to the eye, which might be of use in the arts. Wishing to satisfy himself as to the extent to which this might be carried, M. Becquerel multiplied his experiments, and arrived at remarkable results. He has obtained various and brilliant tints, which he compares to those presented by the wings of tropical beetles. The articles which receive these tints acquire more brilliancy when they are rubbed with leather and jewellers' rouge; that is, the coatings which produce them have a strong adherence—the bronzing rendering the surface more brilliant, determines the reflection of a greater quantity of light, and, consequently, must increase the brilliancy of the color.

The principle upon which the coatings are formed, is, that whatever be the surface of the metal, such will be the deposited coat, so long as it is thin; but as the deposit takes place when the metal is electro-positive, that is when the oxygen tends to oxidize the surface, (if the metal be oxidizable) the coloring effects are only produced with non-oxidizable metals, such as gold, or gilded copper, the surface of which is brightly polished. Thus gold is the metal upon which the rich colors, shown by M. Becquerel to the Academy, were deposited. These effects were produced only by the solution of protoxide of lead in potassa. It requires but one or two pairs of plates, but the operation must be carefully watched, for it lasts sometimes not more than a minute. The colors obtained are light-red, flame-red, deep-red, violet-blue, and finally, a very deep color. The articles must be continually withdrawn from the bath, in order to obtain the tint wished for. If the action be too strong, the hydrated peroxide of lead is formed, which is precipitated in yellow floculi through the solution, without the production of the colors. It is, therefore, necessary to watch the operation every instant, which is so easy, that a number of articles may be operated on at the same time, and always with the same success. M. Becquerel has hitherto confined himself to the effects produced by oxides of lead and iron; in another communication he will give the results obtained with other oxides.—*L'Inst.*

A new and easy method of covering Copper and Brass with Platina.

One part of solid chloride of platina is dissolved in 100 parts of water, and to this solution is added 8 parts of common salt; or, still better, 1 part of platino-chloride of ammonia, and 8 parts of hydrochlorate of ammonia are placed in a flat porcelain vessel, 32 to 40 parts of water poured over it, the whole heated to boiling, and the vessels of copper or brass, perfectly bright, are placed therein. They will be covered in a few seconds with a brilliant and firmly adhering layer of platina.

There is no doubt that this method may be employed with the greatest advantage in pharmaceutical laboratories.

Annals of Chemistry.

On Tinning and Zincing Copper and Brass by the moist way.

Plates of copper, or brass, placed in a boiling solution of stannate of potassa mixed with turnings of tin, are, in the course of a few minutes, covered with a firmly attached bright layer of tin—a method very useful for tinning pharmaceutical instruments.*

A layer of zinc may also be obtained on the same metals by employing chloride of zinc: pure zinc turnings being present. The same object can be attained by means of zinc, and a solution of hydrochlorate of ammonia.—*Boettger's Beitrage.* Ibid.

On colored Fires.

There are very many receipts for colored fires, differing in some slight degree from each other. The following, I believe, *from experience*, to be the best:—

Red fire.—Sulphur, 1 ounce; sulphuret of antimony, 1 ounce; chlorate of potass, 1 ounce; nitrate of strontian, 5 ounces. The chlorate of potass, being previously well powdered, should be mixed carefully on a paper with the sulphuret of antimony, and afterwards the remaining ingredients should be added, and well mixed with a spatula on paper.

Blue fire.—Nitrate of barytes, 77 parts; sulphur, 13 parts; chlorate of potass, 5 parts; realger, 2 parts; charcoal, 3 parts. Mix them thoroughly.

Purple.—Lamp black, 1 part; realger, 1 part; nitre, 1 part; sulphur, 2 parts; nitrate of strontian, 16 parts; chlorate of potass, 5 parts. Ibid.

Researches on certain circumstances which influence the temperature of the Boiling Point of Liquids. By M. F. Marcet.

Philosophers generally admit that the temperature at which any liquid enters into ebullition, depends, 1st. On the nature of the liquid;

* "The same experiment," remarks Mr. Witztein, "was performed by Trommsdorff fifty years ago." I will here give his own words (in Götting's Taschenbuch für Scheidekünstler, and Apoteker Jahrgang, 1791, s. 128,) on this subject.

"*Singular Tinning by the moist way.*—Several vessels of pure English tin were boiled in a portion of caustic ley, in order to clean them. The ley was decanted, and remained standing during one night, in a copper kettle, for further use. The following day, when the kettle was employed, the surface of it, so far as it had been covered by the ley, was discovered to be tinned; and the kettle was used for a long time before this tinning was worn out. Although this might not prove a very economical means for tinning vessels, it might, perhaps, be employed with advantage in those vessels, the shape of which does not admit of their being tinned in the common way."

Further, he states, in the same work, in the year 1792, p. 193:—

"Last year I announced to the public the observation, that caustic fixed vegetable alkali dissolves zinc by the moist way, and is precipitated therefrom in a metallic form by copper: I have since repeated the experiment with complete success. Caustic mineral alkali, and volatile mineral alkali, show the same phenomenon, but it does not always succeed so well as with vegetable alkali."—*Buchner's Repert.*

2nd. On the atmospheric pressure; 3rd. On the nature of the vessels in which ebullition takes place. It is to this last point that M. Marcet has particularly directed his attention; and after an immense number of experiments, he has arrived at the following conclusions:—1st. That the boiling point of water, in glass vessels, varies between 212.54° and 215.6°, according to different circumstances, and particularly according to the quality of the glass employed. In every case the temperature of the steam furnished remained sensibly the same, and is constantly lower (the fraction of a degree) than that furnished by water boiling in a metallic vessel.

2nd. Whatever the nature of the vessel employed, the temperature of the steam furnished is always beneath that of the boiling liquid which furnishes it. When glass vessels are employed, this difference, at a medium, is 1.9° F.; if metallic vessels be employed, it varies from 0.27° F. to 0.36° F. There is only one exception to this rule, which is, when the vessel, whether of glass or of metal, is covered with a thin layer of sulphur, or shellac, or any analogous substance, having no sensible attraction for water. In this case only, the temperature of the vapor is found identical with that of the boiling liquid which furnishes it.

3rd. Contrary to the generally received opinion, a certain temperature being given, it is not in a metallic vessel that the temperature of boiling water is at the lowest possible degree; for it will be found that in a glass vessel covered with a thin layer of sulphur, shellac, or any other similar substance, this temperature is, by some fifths of a degree, lower than in a metallic vessel.

4th. In vessels made of perfectly pure glass, free from any foreign matter, water, and also alcohol, may be heated, without ebullition taking place, to a temperature much higher than has been hitherto usually believed. We may in particular obtain, in this manner, water (not boiling) heated to 221° F.: if this does not happen in every case, it will be found that the surface of the glass is not perfectly smooth, although apparently so, and that it contains foreign matters, which are adherent thereto, and which may be removed by different methods, more particularly by the action of concentrated sulphuric acid.—*Ann. de Chimie.* Ibid.

Test for Copper.

Verguin observed, by chance, that copper may be disengaged, in the metallic state, from any solution containing it, by feebly acidulating the liquid with muriatic acid, and placing it in a capsule formed with platina foil: over this must be arranged a piece of tin plate in such a manner as to touch both the liquid and platina. A deposit of metallic copper on the surface of the platina ensues, which is firmly adherent, and maintains its metallic lustre. The metals should be perfectly clean.—*Ph. C. Bl.* Ibid.

METEOROLOGICAL OBSERVATIONS FOR JULY, 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Baromtr. Sun Rise.	Baromtr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	71°	92°	29.86	29.86	SW.	Moderate		Clear.	Clear.
	2	77	93	29.80	29.80	SW.	do	.59	Clear.	Rain.
	3	60	73	29.75	29.75	NW.	Brisk		Clear.	Clear.
☾	4	55	78	30.00	30.00	W.S.	do		Clear.	Clear.
	5	66	71	29.90	29.90	W.	do		Cloudy.	Cloudy.
	6	56	78	29.94	29.94	W.E.	do		Clear.	Clear.
	7	60	81	29.95	29 95	W.	do	.16	Par. Cloudy.	Rain.
	8	65	78	29.70	29.70	W.	do		Clear.	Clear.
	9	66	83	29.80	29.80	SW.	do		Clear.	Clear.
	10	67	79	29.80	29.80	SW.	Moderate		Par. Cloudy.	Cloudy.
☉	11	68	63	29.74	29.74	NE.	do	.55	Par. cloudy.	Rain.
	12	65	68	30.00	30.00	NE.	do	.03	Cloudy.	Rain.
	13	64	67	30.16	30.20	NE.	do		Cloudy.	Cloudy.
	14	64	75	30.20	30.15	W.	do		Cloudy.	Cloudy.
	15	68	80	29.95	29.90	W.	do	.75	Cloudy.	Showery.
	16	65	81	29.90	29.90	S.	do		Fog.	Clear.
	17	68	74	29.90	29.90	S.	do		Fog.	Cloudy.
	18	72	87	29.76	29.75	W.	do		Cloudy.	Par. cloudy.
☽	19	70	86	29.75	29.75	W.	do	.03	Clear.	Rain.
	20	62	76	29.75	2 .82	NW.W.	Brisk		Cloudy	Clear.
	21	56	77	29.87	29.87	NW.	Moderate		Clear.	Clear.
	22	58	80	29.90	29.90	W.	do		Clear.	Clear.
	23	64	82	29.86	29.86	W.SW	do		Lightly cloudy.	Clear.
	24	68	88	29.80	29.74	SW.	Brisk		Lightly cloudy.	Clear.
	25	66	81	29.90	29.93	NE.	Moderate		Par. cloudy.	Clear.
	26	63	83	30.06	30.06	W.	Brisk		Clear.	Clear.
⊗	27	68	89	29 94	29.94	SW.	Moderate		Clear.	Lightly cloudy.
	28	79	90	29.94	29.90	SW.	do		Clear.	Clear.
	29	76	92	29.80	29.76	SW.	Brisk		Hazy.	Par. cloudy.
	30	76	82	29.75	29.67	NE.	Moderate	.03	Cloudy.	Rain.
	31	62	66	29.85	29.90	NE.	do	.90	Rain.	Clear.
		65.97	79.70	29.88	29.88			3.04		

Thermometer. Max. 93, on 2nd. Min. 55, on 4th. { Mean, 72.87

Barometer. Max. 30.20 on 13th & 14th. Min. 29.67 on 30th. { Mean 29.88

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	1	62°	76°	29.90	29.90	NE.	Moderate		Cloudy.	Par. cloudy.
☾	2	60	79	29.84	29.84	NE.SE.	do		Cloudy.	Par. cloudy.
	3	64	81	29.95	30.00	NE.SE.	do		Cloudy.	Par cloudy.
	4	65	81	30.14	30.25	E.	do		Par. cloudy.	Par. cloudy.
	5	66	70	30.20	30.15	N.	do	3.80	Cloudy.	Rain.
	6	65	76	30.00	30.00	W.	do		Par. cloudy.	Clear.
	7	67	78	30.00	30.00	E.	do	.07	Showery.	Cloudy.
	8	74	77	29.90	29.90	W.	do		Cloudy.	Showery.
☉	9	68	69	29 90	29.96	E.	do	1.65	Rain.	Cloudy.
	10	66	69	29.94	29.86	NE.	do	.15	Par. cloudy.	Rain.
	11	66	76	29 80	29.84	W.	do		Cloudy.	Clear.
	12	64	77	29.86	29.90	W.	do		Par cloudy.	Clear.
	13	66	82	29.90	29.90	SW.	do		Hazy.	Lightly cloudy.
	14	66	82	29.85	29.75	W.SW.	do	.35	Fog—clear.	Rain.
	15	68	79	29.70	29.70	W.	do		Cloudy.	Clear
	16	66	80	29.80	29.85	NW.	do		Cloudy.	Clear.
	17	66	81	29 85	29.90	SW.	do		Fog.	Clear.
☽	18	69	83	29.85	29.85	SW.	do		Fog.	Clear.
	19	71	81	29.85	29.85	SE.	do	.15	Cloudy.	Rain.
	20	68	78	29.85	29.80	E.	do		Par. Cloudy.	Clear.
	21	68	78	29.85	29.84	E.	do	.70	Cloudy.	Showery.
	22	70	77	29.84	29.84	W.E.	Calm	.49	Rain.	Par. cloudy.
	23	70	76	29.86	29.86	W.	do	.05	Cloudy.	Rain.
	24	65	78	29.88	29.90	W NE.	do		Cloudy.	Clear.
⊗	25	66	79	29.98	29.98	NE.	do		Cloudy.	Clear.
	26	68	80	30.00	30.00	SW.	Moderate		Cloudy.	Clear.
	27	68	82	30.00	30.00	SW.	do		Cloudy.	Clear.
	28	72	77	30.00	30.00	SW.	do	.40	Cloudy.	Rain.
	29	70	80	30.00	30.05	NE.	do		Cloudy.	Par cloudy.
	30	71	82	30.05	30.00	E.	do		Cloudy.	Clear.
	31	72	86	29.94	29 80	W.	do		Par. cloudy.	Clear.
		67.32	78.36	29.92	29.92			7.81		

Thermometer. Maximum 86 on 31st. Minimum 60 on 2nd. { Mean, 72.34

Barometer. Max. 30.25 on 4th. Min. 29 70 on 15th. { Mean, 29.92